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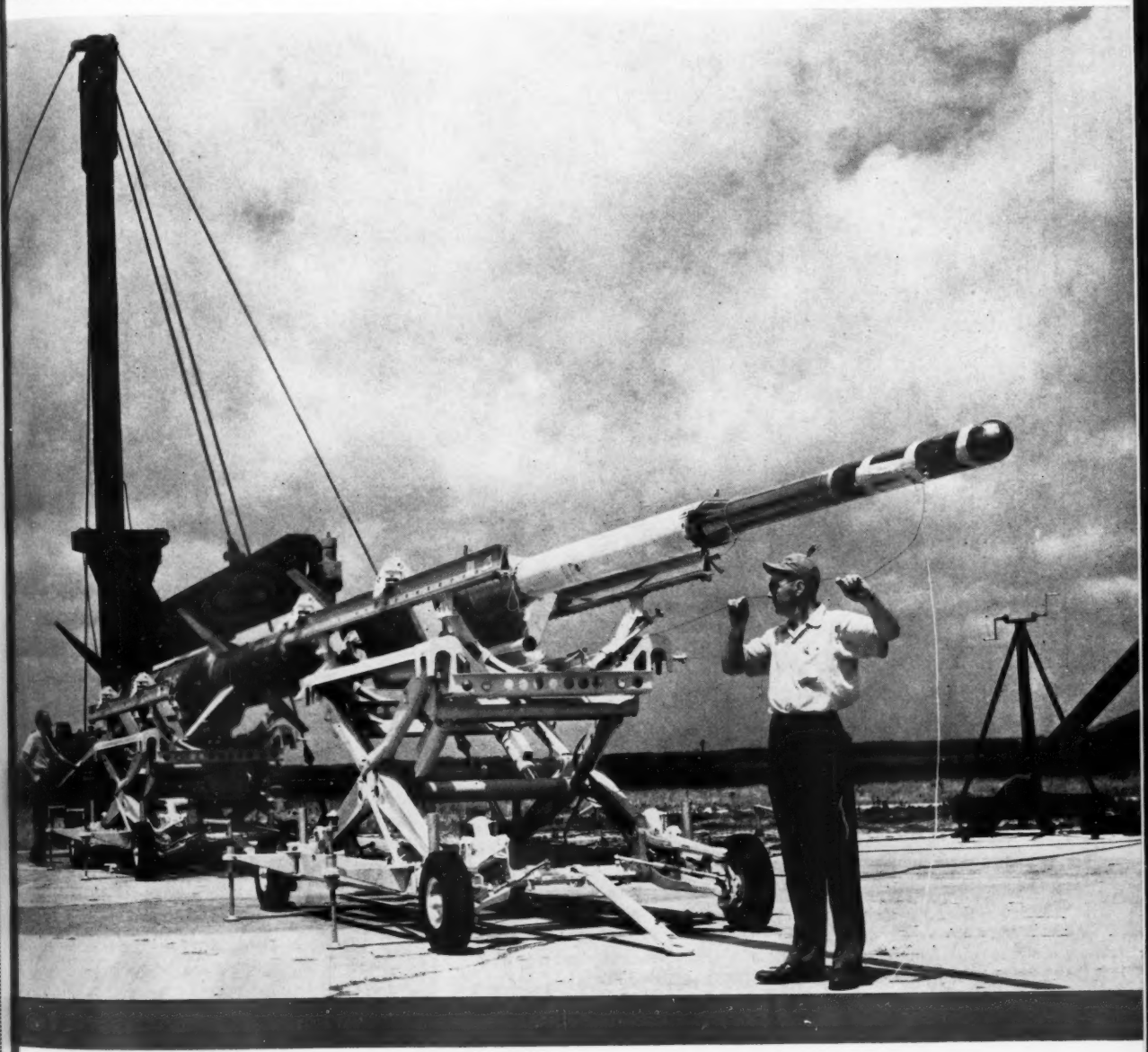
AERO/SPACE ENGINEERING

REVIEW OF CURRENT AND FUTURE TRENDS IN AIRCRAFT • MISSILES • ROCKETS • SATELLITES • SPACECRAFT



In this issue

A FEW VON KÁRMÁNISMS
Guest Editorial

JUNE | 1959

XUM

STEPS IN THE RACE TO OUTER SPACE

Nuclear Rocketship

Despite the sky-high transportation costs, Lunar manufacturing should prove economically viable. With unlimited Solar power, controlled atmospheres and advanced automation, a considerable commerce could be realized in delicate instruments, rare minerals, reactor cores and other items that might be more efficiently processed or produced in the Moon's perfect vacuum.

To supply the Moon colonists, and to carry their production back to Earth, special rocketships will be developed. Nuclear energy is the most promising source of propellant power. The ship shown here utilizes nuclear fission for heat and hydrogen gas as a working fuel. From pressurized tanks, the gas is fed through a heat exchanger, expanded, and expelled for the motive thrust.

When the craft leaves Earth, it carries only enough gas for a one-way trip. For, by extracting hydrogen and oxygen from Lunar rocks, Moon settlers will be able to refuel the rocketship for the return voyage. This will permit smaller fuel tanks on the craft and larger payloads.

Inertial navigation systems will play an increasing role in the exploration of outer space. ***ARMA*** is actively supporting the Air Force's program in long range missiles and is in the vanguard of the race to outer space. ***ARMA***, Garden City, N.Y. A Division of American Bosch Arma Corp.

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XUM

THROUGH

Stretched Acrylics BY GOODYEAR

You are looking through an airliner window of stretched acrylic.

The plane is a Fairchild F-27—but it could be a Boeing 707 or Douglas DC-8. For all of these airliners—and some of the latest military jet aircraft as well—are using stretched Plexiglas* for windows and canopy bubbles.

Leading fabrication techniques and design criteria for low-cost mass production of stretched acrylics have come from Goodyear Aircraft Corporation—pioneer in this important field.

Goodyear Aircraft stretches Plexiglas in such a manner that it is transformed into a tough, durable, craze- and crack-resisting material without the loss of the fine optical properties for which acrylics are known.

These same techniques make possible Goodyear acrylic visors for pilot helmets—protecting their eyes without impairing their vision.

For facilities, experience and skills in all phases of acrylics fabrication—including similar operations and stretching and forming—the company to contact is: Goodyear Aircraft Corporation, Dept. 916AC, Akron 15, Ohio.

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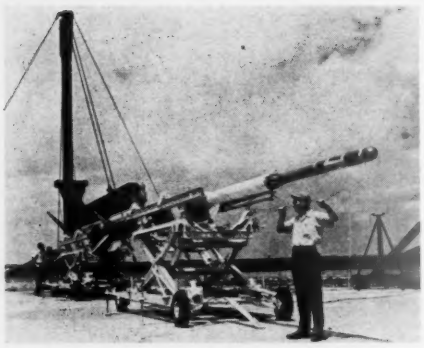
*Plexiglas is a trade-mark of Rohm & Haas Company, Philadelphia, Pa.

On our cover



An NASA photo shows the Argo E-5 research missile used during Project Argus to test theories on radiation about the earth, entrapment of electron particles by its magnetic field, and other phenomena still classified. The E-5 is one of the Argo family of sounding rockets produced by Aerolab Development Company, Pasadena, Calif. Based on "standard" multi-stage rocket configurations in tandem as originally suggested by NASA, it is a five-stage vehicle, 57 ft. overall, weighing 7,000 lbs., capable of carrying 50 lbs. of instruments to more than 500 miles altitude. Aerolab was the prime contractor on Project Jason, a measurement segment of the space nuclear bomb test, under contract to the Air Force Special Weapons Center. In preparation for the shoot, the company designed, built, and launched, from three widely separated bases, more than 20 E-5's and achieved a rate of launching from a single launcher of 4 hours between firings for all assembly and count-down procedures. The E-5 also is becoming known as the Jason missile.

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AERO/SPACE ENGINEERING

VOLUME 18 / NUMBER 6 June 1959

Featured in this issue

A Forum 7 Letters to the Editor
All readers are invited to voice their opinions—technical or otherwise.

The International Scene 13 Seventh Anglo-American Aeronautical Conference Scheduled for United States
British, Canadians, Americans to present technical papers in New York City; Field trips planned for British delegates.

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A proposed answer to the need for a rational, economical design method.

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Demands on radome materials are increasing with higher speeds of missiles.

James D. Hardy and Carl C. Clark, U.S. Naval Air Development Center 48 The Development of Dynamic Flight Simulation
Much more simulation of flight has to be done. Actual flights may be few; training will be long and arduous.

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...NEWS IS HAPPENING AT NORTHROP

Demonstrating the platform of LINS – new, Lightweight Inertial Navigation System – is Dr. William F. Ballhaus, Vice President and General Manager of Nortronics.

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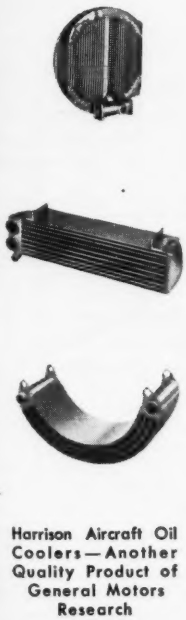
ON HEAT PATROL FOR FLYING MARINES!



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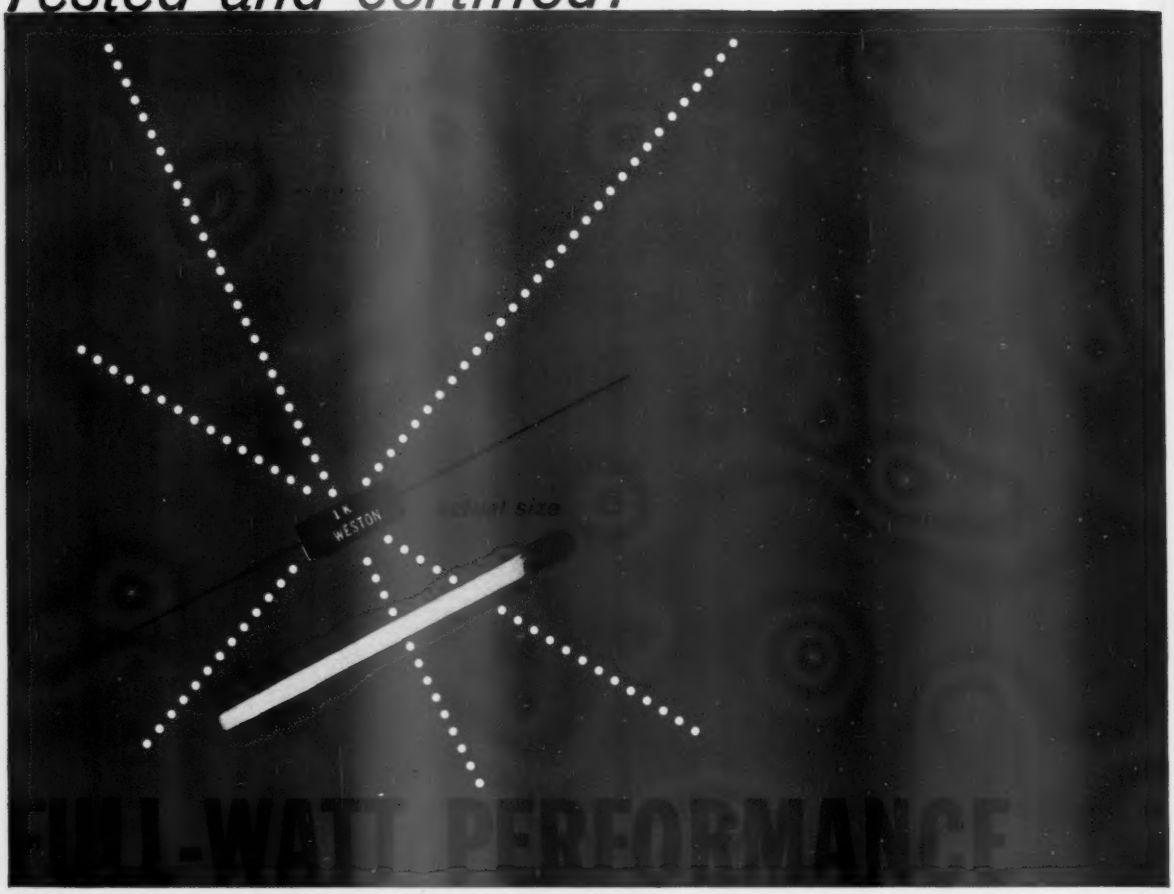

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LETTERS to the Editor

Liked Our April Issue

■ . . .Wanted to extend my congratulations on an excellent presentation. . . .

Nelson Fuller
Mgr. of Res. & Historian, Convair

■ Congratulations on an exceptionally fine April issue! The cover drawing is a beauty and the editorial material supplementing it is very timely, meaty, and interesting. I've read it all.

Robert B. Hitchcock
Adv. Mgr., Janitrol Aircraft Div.
Surface Combustion Corp.

■ I should like to congratulate you and your staff on a fine achievement. . . . In general, I felt that the arrangement of the articles—starting with an overall view of the national space program, and progressing from the motions of the earth, to space flight in the X-15, then out into satellite orbits with its communication problems, and back again to earth—was particularly well organized, and runs parallel, step by step, with the actual development expected in flight into space. **Harry Esses**
Senior Engineer
Gen'l. Applied Science Labs., Inc.

■ My congratulations to you and to your staff. . . . An interesting and readable issue. **H. Guyford Stever, M.I.T.**

■ I'm sure the entire issue will be very informative for the many engineers who are now becoming involved in space flight projects. **R. H. Parvin**
Sr. Systems Engr., Aero. Div.
Minneapolis-Honeywell Regulator Co.

■ The format and content. . .are very impressive. **Clayton C. Clark, Jr.**
Weapon System Rep.
North American Aviation, Inc.

The Editors wish to thank not only the above for their expressions, but also the writers of other similar letters not published in the interest of editorial space economy.—ED.

Hits "Grounded Bumbling"

■ This is a parting shot from an ex-member of the IAS.

Two years ago it became clear that the Institute was to remain dominated by airplane executives to the extent that the technologies of missiles and astronautics were de-emphasized. This complaint is not so valid today, but the aftereffects of editorial conservatism are evident in the publishing of less-qualified astronautics writers.

For example, I cite Comdr. Hoover's piece on "Man-Machine Integration in Space Vehicles" (*A/SE*, Feb., 1959). This is a modified version of a rather severe blast which he aimed at the quick-man-in-space enthusiasts about a year ago in a paper presented before the AAS. It seems to be his habit to imply controversy—in this case, over the issue of whether the man should be a pilot or simply a passenger in the early space probes—and, having set up the "straw man," he proceeds to demolish it with the point that ultimately men in space will require full control over their communication and navigation.

The sensible point that seems to elude that author is the rational timing of (1) ballistic experiments with competent subjects, (2) aeroballistic test vehicles such as the X-15B which will permit piloting to a certain extent, and (3) reaction-controlled wingless space vehicles.

Acknowledging the sincere interest of former "human engineers" in the human-factors work which must precede launching of fully piloted spacecraft, readers should consider whether well-planned early experiments are not worth priority over the "grounded" bumbling which has been typical of many aircraft control design theorists. **Member, AAS**
St. Louis, Mo.

On Battery Performance

■ It was a pleasure to read the interesting article "Electronic and Communications Aspects of Space Flight" in *A/SE* for April.

We are surprised to see, however, the low-performance figure given for Silver Peroxide Zinc batteries. Rather than the 15-watt hours per pound at the high (10 min.) discharge rate which you give, our flight qualified Atlas missile primary battery cells, for example, yield over 50 watt hours per pound at the 10-min. rate. High-efficiency space application packaging will not reduce this appreciably. Also, rather than an activated life of 2 weeks, these Atlas batteries have a wet stand in excess of 60 days. In addition, secondary battery designs for long life are meeting operating specifications after over a year's cycling.

Frank R. Cook
Pres., Frank R. Cook Co.

Complexity—A Headache!

■ The letter by William Littlewood, Vice-President—Equipment Research, American Airlines, which appeared under Letters to the Editor in the January issue of *A/SE*, struck a responsive chord with this reader. As designers, developers, and manufacturers of equipment which is installed and used aboard today's new aircraft, we too are often concerned with the increasing complexity of many of the devices which are requested.

In many cases we can see where a simpler device could fulfill the necessary function, with lower cost and with greater reliability. However, we can only advise and suggest; the final decision rests with the customer, and, if the customer insists, we have no choice but to satisfy his desires.

It is not that the customer insists on complexity, high cost, or unreliability, but very often the customer does insist on a performance requirement or a configuration which is not completely realistic and which can only be met by incorporation of complexity which increases the cost of the item and reduces its reliability. This trend toward complexity and "gadgetry" to attain unrealistic performance requirements seems to be common not only with the commercial and private aircraft, but with the military services as well. There was a time when prospective users of the equipment would consult with manufacturers to find out what could reasonably and practically be attained. Now, however, the more usual practice is for someone to write a detailed specification and then in effect challenge the manufacturers to either accept the specification or forego the business. In many cases, specification requirements are unrealistic and often reflect an impractical attitude and even a lack of "knowledge of the art." Yet if the manufacturer questions the specifications, he is usually challenged to prove that "it can't be done." The manufacturer who closes his eyes to the impractical aspects and to the difficulties involved in meeting the specifications is the one who obtains the business. Often he may find (and it may be mutually agreed, months or even years later) that the entire concept was impractical and that "it simply can't be done," but in the meantime valuable time has been lost and much time and money has been expended. Or, a device may be developed (and actually put into production and use) which meets the specification requirements but which has undesirable features which were not anticipated by the specification.

Attempts to combat this trend toward complexity and unnecessarily meticulous performance requirements are seldom successful; we have often tried to promote the acceptance of less precise, simpler, but more reliable equipment. On a few occasions we have succeeded, but on many others we have had to accept the prospective purchaser's requirements even with misgivings.

Change and improvement are not always synonymous. Only when they are do they contribute to progress. Gadgetry in itself is not progress, unless the gadgets help achieve new benefits without sacrificing any of our past gains in reliability.

We share with Mr. Littlewood his feeling that there is a need for a proper appreciation of practical performance, of making things simple, rugged, dependable, and safe, and that reliability can be improved only by the adoption of more practical attitudes and by the attainment of more practical experience by the people responsible for drafting of specifications.

Arthur E. Miller
Dir. of Res., Scott Aviation Corp.

SARGENT

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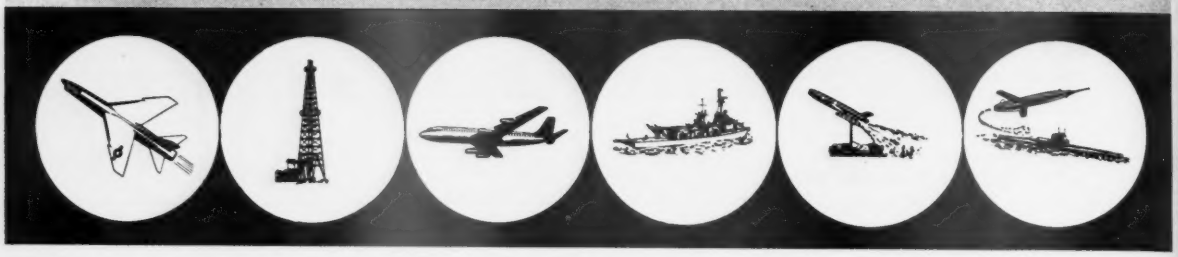

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– U.S. Supreme Court

the Green Sheet

IAS BULLETINS AND LATE NEWS . . .

June - 1959

MANNED SPACE STATIONS -- A NATIONAL MEETING ON THIS SUBJECT WILL BE HELD BY THE INSTITUTE, IN COOPERATION WITH NASA AND THE RAND CORPORATION, ON APRIL 20-22, 1960, AT THE AMBASSADOR HOTEL, LOS ANGELES. ABOUT 50 PAPERS WILL BE PRESENTED IN SESSIONS TO TAKE UP CURRENT STATUS, DESIGN CONCEPTS, HUMAN FACTORS, ORBITAL RENDEZVOUS, STRUCTURES, ENERGY SOURCES AND GUIDANCE-CONTROL -STABILIZATION.

ALL SEVEN IAS REGIONAL STUDENT CONFERENCES for 1959, just completed, recorded the largest overall attendance to date. More students (over 600) read more papers (117); and, in the estimation of Conference judges, the caliber both of delivery and content was consistent and impressive. A complete conference report is scheduled for an early issue of A/SE.

COMING NEXT MONTH: To give those of its readers unable to attend this month's IAS National Summer Meeting the latest technical data quickly, Aero/Space Engineering for July is publishing several articles recommended by the NSM Committee. IAS members and other A/SE subscribers interested in Materials, Structures, Aerodynamics, Spatial Navigation, Propulsion, Electronics, and Supersonic Aircraft, are alerted to watch for their July National Summer Meeting issue.

THE 1958 GROVER E. BELL AWARD was presented at the annual Honors Night Dinner of the American Helicopter Society to engineers of Vertol Aircraft Corporation for the "development of the Vertol 76, the first tilt-wing aircraft to perform successful transition from vertical to horizontal flight and back." Lee L.Douglas, AF-IAS, Vertol's Vice President-Engineering, accepted. Presentation was by Leston Faneuf, AIAS, President, Bell Aircraft Corporation. Selection is made annually under terms of the will by a Committee of three holding the following offices: President, AHS; President, IAS; and Chairman, Helicopter Council, Aircraft Industries Association. (The Vertol 76 was subject of a technical article published in A/SE last February entitled "Flight Testing Experiments With the Tilt-Wing Aircraft", by W. Z. Stepniewski, AFIAS, Assistant Vice President of Engineering for Research, and Paul J. Dancik, Project Engineer, of Vertol.)

THE NAME OF ROBERT H. GODDARD, rocket research pioneer, (who received the IAS-administered Louis W. Hill Space Transportation Award posthumously in January) will be further perpetuated by the Government. NASA's new space projects facility on 550 acres at Greenbelt, Md., will be named the Goddard Space Flight Center. Robert R. Gilruth, FIAS, is Assistant Director-Manned Satellites.

THIS MAGAZINE'S 1959 READERSHIP SURVEY, entailing the mailing of thousands of reply postcards to determine reader preferences and habits, has been concluded, and a week's work by accountants in classifying various data also has come to a close. This revealing sampling of the tastes and needs of our readers will be dealt with in next month's editorial, with some commentary on the policy of Aero/Space Engineering and its role as an arm of the IAS. Meanwhile, returns on the Institute's Professional Interest Survey are mounting in the office of Director S. Paul Johnston.

INTERNATIONAL, NATIONAL AND JOINT MEETINGS CALENDAR

June	11-13	Heat Transfer and Fluid Mechanics Institute, Univ. of California, Los Angeles. IAS participating.
June	16-19	IAS National Summer Meeting, Ambassador Hotel, Los Angeles.
Aug.	24-26	National Specialist Meeting Symposium on Anti-Submarine Warfare (Classified), San Diego, Calif.
Sept.	9-11	Midwestern Conference on Fluid and Solid Mechanics, University of Texas. Cosponsors: IAS, AFOSR, ONR, NSF, and eleven technical societies. For added information, contact Dr. M. J. Thompson, Chairman, Dept. of Aeronautical Engineering, Univ. of Texas, Austin 12, Texas.
Sept.	16-17	Western Regional Meeting on Frontiers of Science and Engineering, Los Angeles.
Oct.	5-7	Seventh Anglo-American Aeronautical Conference (technical sessions only), Hotel Astor, Times Square, New York.
Nov.	2-4	Midwestern Meeting on New Frontiers in Aviation, Hotel Lassen, Wichita, Kansas.
Nov.	17-18	National Air Transportation Meeting, San Francisco, California.
Dec.	17	Wright Brothers Lecture, National History Building Auditorium, Smithsonian Institution, Wash., D.C.
	1960	
Jan.	25-28	IAS 28th Annual Meeting, Hotel Astor, Times Square, New York.
Sept.	12-16	2nd International Congress, International Council of the Aeronautical Sciences, Zurich, Switzerland.

IAS SECTION MEETINGS CALENDAR

June	2	New Mexico: Dinner Meeting, Leonard's Restaurant (6616 Central, SE, Albuquerque), 6 p.m. "Integrating Jets into TWA", by Marcy B. Fannon, Coordinator of Jet Planning, Trans World Airlines.
June	6	Texas: Field Trip, Chance Vought High Speed Wind Tunnel.
June	13	San Diego: Field Trip, Paul Mantz Airport.

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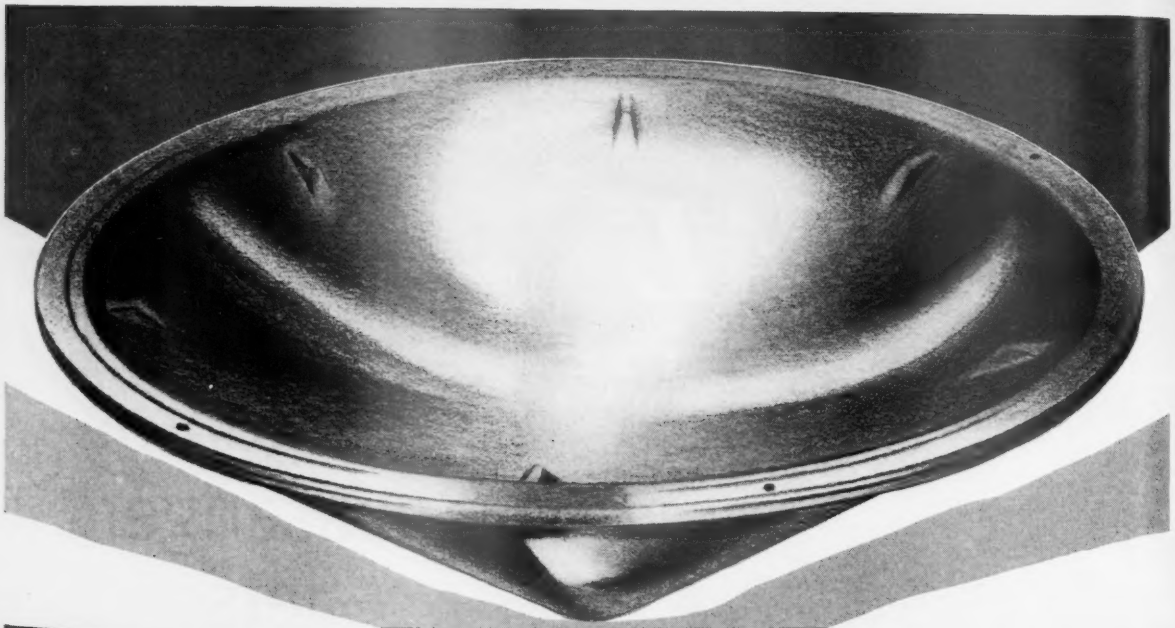

RE-ENTRY SHIELDS

EST. 1883

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- Copper in production
- Beryllium in limited production
- Reinforced plastics in development

WYMAN-GORDON

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DETROIT, MICHIGAN
GRAFTON, MASSACHUSETTS
FORT WORTH, TEXAS
FRANKLIN PARK, ILLINOIS
LOS ANGELES, CALIFORNIA

IAS News

. . . a record of people and events of interest to Institute Members

Seventh Anglo-American Aeronautical Conference Scheduled for United States

British, Canadians, Americans to Present Technical Papers in New York City; Field Trips Planned for British Delegates

THE TENTATIVE PROGRAM of technical sessions for the Seventh Anglo-American Aeronautical Conference, October 4–17, lists nine British, two Canadian, and ten American technical papers. They will be presented at the Hotel Astor, New York City, October 5–7.

The proposed British papers are:

"Work of the Blind Landing Experimental Unit" by W. J. Charnley, Ministry of Supply, Bedford.

"Propulsion Units for VTOL" by H. Pearson, Rolls-Royce, or Dr. S. G. Hooker, Bristol Aeroplane Co.

"Aerodynamic Design of Wings and Bodies for Transonic and Supersonic Applications" by Dr. D. Küchemann, Royal Aircraft Establishment.

"Thermal Stresses (or Related Problems)" by Prof. J. H. Argyris, Imperial College.

"Design Philosophy for High Acceleration and Elevated Temperature" by B. O. Heath, English Electric Co.

"Recent Studies of Satellite Orbits" by E. C. Cornford, Royal Aircraft Establishment.

"Boundary-Layer Separation in Supersonic Flow" by Dr. D. W. Holder and G. E. Gadd, National Physical Laboratory.

"The Fail-Safe Concept" by R. J. Atkinson, Royal Aircraft Establishment, and Dr. C. J. Strang, Bristol Aeroplane Co.

"Unresolved Civil Airworthiness Problems" by W. Tye, Air Registration Board.

The proposed Canadian papers are:

"Aircraft Dynamics Under Very High Speed and Altitude Conditions" by Dr. G. V. Bull, Canadian Armament Research and Development Establishment.

"VTOL/STOL" by R. D. Hiscocks, Assistant Chief Engineer, DeHaviland Aircraft of Canada Ltd.

The proposed American papers are:

"Similarity and Flight Simulation in Hypersonic Test Facilities" by A. H. Flax, Cornell Aeronautical Laboratory, Inc.

Peter G. Masefield
Managing Director, Bristol Aircraft Ltd.
1959 President, RAeS

"Instrumentation for Space Science Research" by John W. Townsend, Jr., NASA, Beltsville Space Center.

"Hypersonic Separated Flows" by S. M. Bogdonoff, Professor of Aeronautical Engineering and Head, Gas Dynamics Laboratory, and Irwin E. Vas, Research Associate, The James Forrestal Research Center, Princeton University.

"Flying Qualities Associated With Several Types of Command Flight Control Systems" by S. A. Sjoberg, NASA, Langley Research Center.

"Ablation in Hypersonic Flow" by Lester Lees, Professor of Aeronautics, Guggenheim Aeronautical Laboratory, California Institute of Technology.

"Interactions Between the External Flow and Rocket Exhaust Nozzle" by C. F. Schueller, NASA, Lewis Research Center.

"New Methods and Concepts in Transient Heat Flow Analysis" by M. A. Biot, Cornell Aeronautical Laboratory, Inc.

"Study of the Stability and Control Characteristics of Atmospheric Entry Type Aircraft Through Use of Piloted Simulators" by Brent Creer, Aeronautical Research Engineer, and Rodney C. Wingrove, Aeronautical Research Engineer, NASA, Ames Research Center.

"Blind Landing and Take-Off of Aircraft" by Nelson Harnois, Lockheed Aircraft Corp.

"Research and Development Program for Future ATC Systems" by Capt. A. C. Packard, Acting Director, Bureau of Research and Development, FAA.

Registration facilities for the technical sessions will be open on the 8th Floor of the Hotel Astor at 8:00 a.m. each day. This portion of the Conference will be concluded on October 7, followed by the Conference Dinner, at the Hotel Astor that evening, to which a nationally prominent personality has been invited as speaker.

A program of field trips for the British delegates has been planned from October 8–17, following the technical sessions. The program schedule tentatively includes visits to: Martin (Baltimore), FAA Facility (Atlantic City) or United Aircraft Corp. (East Hartford and Bridgeport); Grumman and Republic (L.I.) or Wright Aeronautical Div., Curtiss-Wright Corp., and Reaction Motors (Paterson and Denville, N.J.); NASA Laboratories, Ford Assembly Plant, and Thompson Products Plant (all in Cleveland); Cornell Aeronautical Laboratory (Buffalo) and Bell Aircraft (Niagara Falls); followed by a bus trip to Toronto and a 2-day visit of the area arranged by the Canadian Aeronautical Institute.

The Conference will be concluded on October 17 in Toronto.

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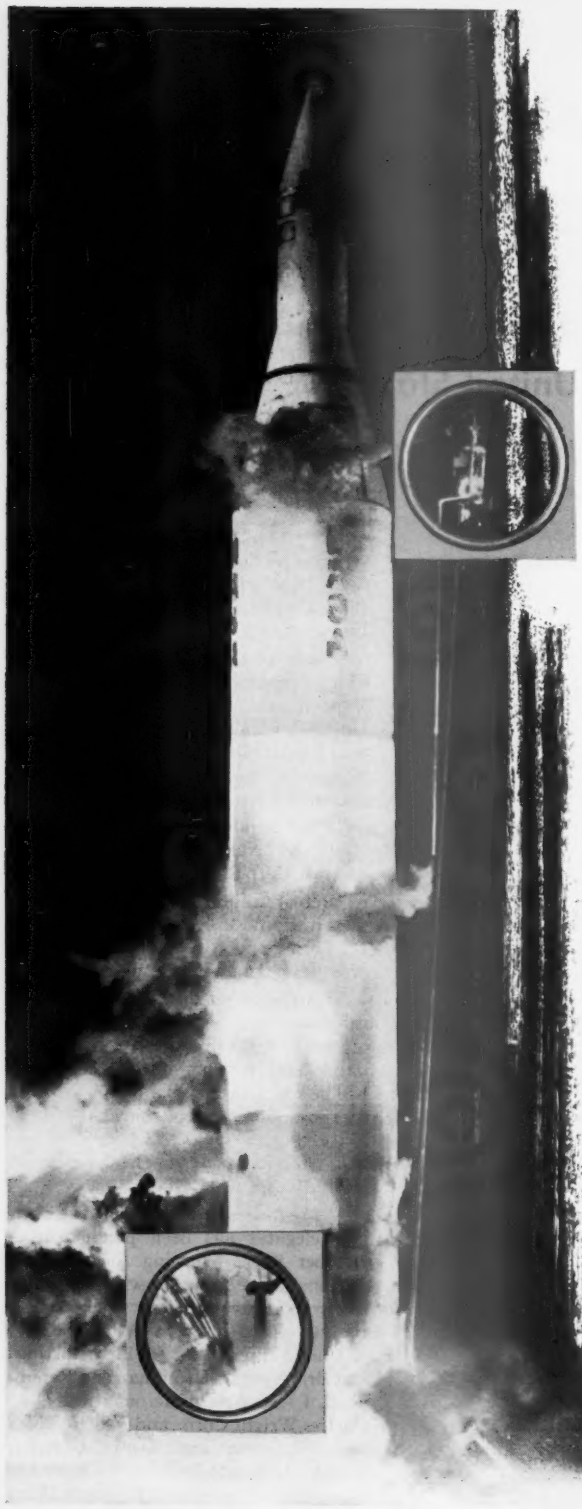

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DMJM Is Welcomed as New Corporate Member

The aeronautical activities of Daniel, Mann, Johnson, & Mendenhall of Los Angeles, new IAS Corporate Member, centers around the planning, designing, and engineering of air bases, airfields, and missile complexes and facilities.

The firm has provided architectural and engineering services on more than 16 military airfields in the United States; 20 airfields in the Far East at such locations as Japan, Korea, Okinawa, Formosa, and Guam; and approximately 60 airbases in the United Kingdom for a total approaching the 100 mark. Assignments in the United Kingdom are part of a continuing consultation service to the U.S. Third Air Force relating to design and planning of all USAF installations under the cognizance of the British Air Ministry.

Daniel, Mann, Johnson, & Mendenhall's work on air base complexes encompasses master planning; engineering of runways, taxiways, and aprons; design of structures such as hangars, maintenance facilities, and housing; and work on navigational aids and utilities, lighting, power supply, POL facilities, and communications.

In the area of missiles and rockets, DMJM has designed facilities for test and training, launching, propellant storage and manufacturing, communications and tracking, and research and development. Such DMJM-designed facilities are located at important missile centers in the country including Vandenberg AFB, Calif., and Cape Canaveral, Fla.

Necrology

Frederick C. Hingsburg

The Institute has been informed of the death of Capt. Frederick C. Hingsburg, USCG (Ret.) (AF), on March 25. He was 70 years of age.

As Chief Engineer, from 1926–1934, of the Airways Division, Department of Commerce, Captain Hingsburg laid out 19,000 miles of airways. He was Superintendent of the U.S. Lighthouse Service from 1918–1925 and 1936–1939.

Captain Hingsburg received B.E. and C.E. degrees from Cooper Union and studied at the Polytechnic Institute of Brooklyn.

He was a recipient of the Victory Medal and was also a member of the American Society of Civil Engineers.

Captain Hingsburg authored many articles on air navigation facilities.

A. R. Weyl

Alfred Richard Weyl (AF) died suddenly on February 23 at the age of 61. Since 1952, he had been an aeronautical engineering consultant.

In World War I, he was a front-line pilot with the German Air Force and, after studying at the Berlin Technical University, served with the Reichsluftamt and the DVL, the aeronautical research center. After being principal assistant to the Chair in Aeronautics at Berlin Technical University and being in charge of R&D projects for the Defense Ministry, he went to the Udet-Flugzeugbau, Munich (which later became the B.F.W., Messerschmitt works) where he designed what is believed to be the first wooden low-wing cantilever monoplane ever flown.

Most interesting of his airplanes was the Kitten, which was built and flown in 1935–1936 by his English company, Dart Aircraft, Ltd. The Kitten ultralight, single seater, of which at least two are still flying, showed the originality of its designer-pilot's mind by the wing shape. By a judicious change of section and incidence at the tip, full aileron control was available at the stall on an unslotted tapered wing for the first time.

Born in Berlin, he took refuge from Nazi oppression in England, eventually becoming a British citizen.

Minta Martin Lecture Delivered at M.I.T.; Repeated Twice

The fourth Minta Martin Lecture was given on March 18 at Kresge Auditorium, M.I.T., by the 1958–1959 Hunsaker Professor, George P. Sutton. Mr. Sutton was recently named by the President as Chief Scientist of the Defense Department's Advanced Research Projects Agency.

The lecture was repeated by Mr. Sutton in cooperation with the University of Maryland and the Washington Section on March 24, and again on May 12 in cooperation with the Guggenheim Aeronautical Laboratory, C.I.T., and the Los Angeles Section.

An authority on propulsion, Mr. Sutton spoke on "Rocket Propulsion Systems for Space Flight." He compared different propulsion systems for interplanetary missions, including liquid and solid propellant rockets, electrical, nuclear and wave propulsion engines. The discussion touched not only on various propulsive mechanism and concepts, but also on the energy source devices. Considerations were limited to the power plants for interplanetary flight and did not include boosters and rockets for landing and take-off from planets.

The lecture was delivered in conjunction with a professorship established at M.I.T. in 1954 to honor Jerome Clarke Hunsaker, a leading figure in aviation and for many years head of M.I.T's Aeronautical Department. Mr. Sutton is the first man from industry to fill this chair. At the time of his appointment, he was Manager of the Advance Design Sub-Division of Rocketdyne, a Division of North American Aviation, Inc.

Dr. Walter Dornberger (AF) has been named Director of Engineering of the Niagara Frontier Division of Bell Aircraft Corp. Dr. Dornberger, who joined Bell in 1950 and has been Technical Assistant to the President, will direct all missile, space flight, aircraft, and rocket engineering efforts in Bell's Buffalo-Niagara Falls operations.

IAS News — News of Members

Robert W. Bratt (M) has been named Chief of Douglas Aircraft Company's new Aerophysics Laboratory, El Segundo, Calif. Mr. Bratt has been with Douglas since November, 1946.

Walter B. Brewer (M), formerly Assistant Head of the Weapon System Design Department, Cornell Aeronautical Laboratory, Inc., has joined Space Technology Laboratories, Inc., as Associate Manager of the Airborne Systems and Test Department, Atlas Program Office.

E. I. Bricker (AF) has been appointed Division Engineer of Lockheed's (Georgia Division) Engineering Research Laboratories. Mr. Bricker was formerly Manager, Mechanical Research Department.

R. F. Brodsky (AF), formerly Chief of Aerodynamics at Convair—Pomona, has become Manager of the Engineering Services Department on the Technical Staff of the Weapons Systems Division, Aerojet-General Corp. The Aerodynamics, Thermodynamics, Stress and Weights, and Dynamics sections will fall under his jurisdiction.

Dean R. Chapman (F), Aeronautical Research Scientist, Ames Research Center, NASA, is the recipient of the Rockefeller Public Service Award for the academic year 1959–1960. The award will enable Dr. Chapman to pursue the study of astronomy and electromagnetic theory at Cambridge University, England.

Dr. Milton U. Clauser (F), Vice-President and Director of Space Technology Laboratories' Physical Research Laboratory, has been named to serve on the newly formed NASA Research Advisory Committee's Electrical Power Plant Systems Committee.

Dr. William C. Cooley (M) has joined

the NASA as Chief of the Space Propulsion and Auxiliary Power Units Program. He was formerly Assistant Program Engineer of the Rover nuclear rocket program at Rocketdyne.

Julius J. Domonkos (A), Vice-President, Bell Aircraft Corp., who was formerly Manager of the Aircraft Division, has been appointed Vice-President—Manufacturing. In his new position, he will be responsible for coordination and direction of manufacturing operations in the subsidiaries and operating divisions, with emphasis on new production and manufacturing techniques, methods, and materials.

Allen F. Donovan (AF), a vice-president, Space Technology Laboratories, Inc., has been named Director of STL's Advanced Systems Planning. He will assume full responsibility for advanced ballistic missiles and space systems planning.

Dr. William M. Duke (AF), Vice-President and Director of Space Technology Laboratories' R&D Division, has accepted the invitation to serve on NASA's Research Advisory Committee on Structural Loads.

Edward E. Foster (AF) has been named Assistant Technical Director for Administration of Cornell Aeronautical Laboratory, Inc. He has been Technical Program Coordinator for the past 3 years.

Brig. Gen. H. F. Gregory, USAF (Ret.) (AF), has been elected to the Board of Directors of Midwestern Instruments, Inc., where he has been associated as Vice-President, Assistant to the President, since his retirement from the Air Force in October, 1958. General Gregory is a member of *A/SE*'s Editorial Advisory Board, serving on its Space Technology Committee.

N. E. Halaby (M) has been appointed to the newly created post of Executive Vice-President, Servomechanisms, Inc. Mr. Halaby, who is Director of the company and its Canadian subsidiary, formerly held the post of Vice-President of Finance and Administration.

Frank W. Heilenday (M) has been promoted to Chief of the Office of Operations Analysis, Hq., Eighth Air Force (SAC), Westover AFB, Mass.

Bennett H. Horchler (A) has been named Assistant to the Publisher of *Aircraft and Missiles Manufacturing*, a Chilton publication. He was formerly Publishing Director of *Aeronautical Procurement*.

Robert E. Kemelhor (M) has joined The Johns Hopkins University, Applied Physics Laboratory, as Senior Staff Member in the Polaris Group. He was formerly Director of R&D, Pesco Products Division, Borg-Warner Corp.

James H. Kindelberger (HF), Chairman of the Board of North American Aviation, Inc., has been awarded the Gen. William E. Mitchell Award for outstanding contribution to aviation progress. The award was presented by Aviator's Post No. 743, American Legion.

Grayson Merrill (AF), General Manager of Fairchild Astrionics Division, has been assigned project responsibility for the SD-5 drone being developed for the U.S. Army by the Fairchild Engine and Airplane Corp. He will have both management and overall technical direction of the program.

Dexter Rosen (AF), formerly Manager of the Planning and Controls Department, Space Flight and Missile Div., Bell Aircraft Corp., has been instrumental in forming an engineering development organization known as The Oxford Corporation. Mr. Rosen is Secretary-Treasurer and Director.

Arthur E. Miller (M), Director of Research, Scott Aviation Corp., has been selected by the Compressed Gas Association Committee on Medical Gases to head a Subcommittee on Air Standards. Purpose of the unit is to establish standards and specifications for compressed air used in several types of respiratory equipment.

Dr. James S. Murphy (M) has been named Assistant Chief of the new Aerophysics Laboratory of Douglas Aircraft Co., El Segundo, Calif.

Lester K. Murray (M), Manager of the Colorado Springs, Colo., office of Convair, A Division of General Dynamics Corp., has been assigned additional duties as Acting Manager of Convair's office at Omaha, Neb., for an indefinite period.

Alfred M. Nelson (M) has been transferred to the staff of the Hq. Office, NASA, Washington, D.C., as an Aeronautical Research Scientist. He was formerly with the Propulsion Laboratory, WADC, Wright-Patterson AFB, Ohio.

J. H. Overholser (M), founder and President of the Hydrodyne Corp., has sold his interest in the company and has accepted the position of Vice-President, Sales and Engineering at Turbo Products, Inc., Pacoima, Calif. He will be in charge of all sales and engineering activities for the firm's five divisions—Awica Clamps, Turbo Products, Lefco Plastics, U.S. Propellers, and U.S. Honeycomb.

Perry W. Pratt (F), Vice-President and Chief Scientist of United Aircraft Corp., has been appointed to serve on the Propulsion Panel of the USAF's Scientific Advisory Board.

Robert H. Shatz (M), formerly Director of Systems Research Division, Cornell Aeronautical Laboratory, Inc., has joined the Missiles & Space Systems Division, United Aircraft Corp., as Chief, Technical Military Planning.

Adolph K. Thiel has been moved up to Program Director for Space Missions, Space Technology Laboratories, Inc. Dr. Thiel was formerly Director of the Thor Program Office.

William H. Zarkowsky (M), Manager of the W2F-1 Program, Grumman Aircraft Engineering Corp., has been appointed to the NASA's Research Advisory Committee on Aircraft Aerodynamics.

IAS News

Corporate Member News

• **Aerojet-General Corp.** has announced the purchase of a minority interest in Technical Research Group, Inc., of New York, and the election of Dan A. Kimball, President of the Azusa and Sacramento, Calif., plants as a Director of TRG. The two companies will work jointly on advanced optical detection systems of interest to the national defense.

• **American Bosch Arma Corp.** was recipient of the first Annual Award for Outstanding Industrial Achievement presented by the Mitchel Squadron Air Force Association.

• **Avien, Inc.,** has announced formation of a new research and advanced development department which will be responsible for exploring new technical areas and the development of advanced concepts associated with space technology, nucleonics, automation, human engineering, and advanced electronics. Seymour Rabinowitz, formerly Manager, Engineering Department, has been named Director.

• **Bell Aircraft Corp. . . .** Niagara Frontier Division has elected two Assistant Vice-Presidents—Stephen B. Elggren, Sales Manager, and Terence M. Nolan, Works Manager.

• **Bendix Aviation Corp.** has named Charles P. Boegli as Supervisory Engineer for the Cincinnati division. He will be responsible for research and development in the field of electronic circuitry, and also will act as a consultant in plastics and mechanical design to other sections of the engineering department. . . . Bendix Products Division has assigned Leroy J. Beckman and Eugene Markus to new West Coast positions. Mr. Beckman will be Southern California Sales Representative for the Airframe Section, and Mr. Markus will be Engineering Representative for the same area.

• **Bulova Research and Development Laboratories, Inc.,** has elected Dr. William Ewart Williams, internationally known

(*Continued on page 102*)

NEW EEMCO PILOT SEAT ACTUATOR BUILT TO TAKE FULL ROCKET BLAST REACTION

Type D-1115
Pilot Seat Actuator

...designed, produced and delivered in 79 days!

TODAY'S MOST RUGGED new seat actuator has been successfully designed by **EEMCO** to take the full blast reaction of a rocket that ejects a pilot seat upward instead of down. This **EEMCO** actuator is a critical part in the retro-fit program that will cover the full production run of one of our latest supersonic fighters. The actuator straddles the rocket...it had to be rugged! Yet weight and space limitations were highly restricted.

The actuator was specified for an ultimate static load of 12,000 lbs. in tension and 4100 lbs. in compression. To insure absolute reliability, no castings were used in the stress path, and subsequent tests indicated buckling and ultimate tensile loads of 12,500 lbs. and 23,500 lbs. respectively. Stroke limits are controlled by non-jamming mechanical stops. This obviates the need for limit switches. The two jacks are synchronized, one made adjustable for easy installation of the actuator in a precise position so that unison of stroke and end stops would not be affected.

This important project assigned to **EEMCO** is being carried out on a tight customer-dictated delivery schedule under **EEMCO's** rigid quality control policy despite the urgency of the program.

Your inquiries are invited when similar critical problems confront you.

NOTE THESE SPECIFICATIONS:

Travel: .34 inches per second
Stroke: 4.5 inches
Normal load: 400 lbs. (200 lbs. per jack)
Compression load: 4100 lbs.
Tension load: 12,000 lbs.
Voltage: 26 volts DC (available as 400 cycle AC)
Weight: 8.5 lbs.
Meets MIL-SPECS E-5272A, M-8609 and A-8064A

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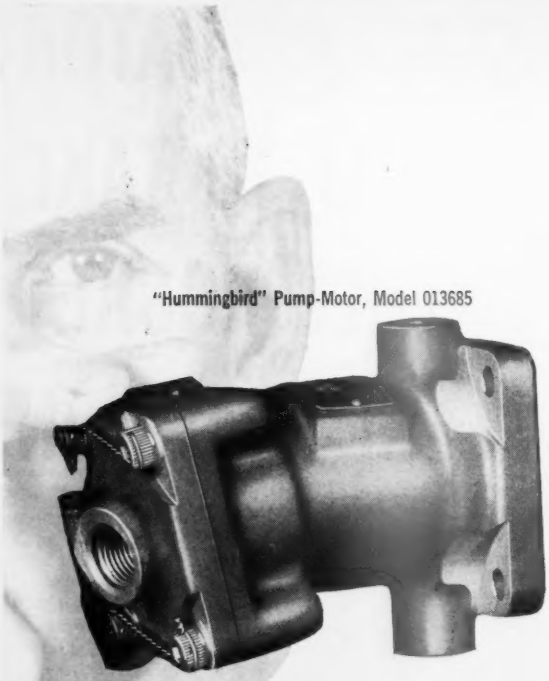

"Hummingbird" Pump-Motor, Model 013685

Creative engineering ...for the space age

Miniature Pump-Motor, a remarkable Pesco development in hydraulics, saves critical space and weight on jets and missiles. Piston-type hydraulic unit can be used as either pump or motor without modification for rotation in either direction. Model shown here delivers 2.5 gpm at 3000 psi, operates at 24,000 rpm from direct drive, weighs 2.1 lbs., handles fluids from —65° to 550° F. All-steel unit features spherical piston ring, all-metal O-rings, constant-velocity universal joint. Basic design can be varied to meet your specifications.

This is but one of many exciting Pesco developments in hydraulic pumps motors, power packages, servo valves.

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The miniaturized pump-motor shown here demonstrates Pesco capabilities for engineering high-performance hydraulic components. These can be applied to your space age program wherever pressurized flow and precise control of fluids are vital.

Creative Pesco engineers are making outstanding contributions to many of the most advanced projects. Working closely with customer engineers, they are meeting the most sophisticated requirements for space and weight savings, environmental resistance and performance of hydraulic accessories and systems.

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DATELINE world

PROFESSIONAL NOTES AND REPORTS

Engineering and Scientific Briefs from Correspondents Around the Globe

Report on Helicopter Rotor Designs, Lubrication

◆ Articulated helicopter rotors require some form of damping mechanism to subdue rotor-blade travel in the lead-lag direction. The damper limits oscillations which, when the aircraft is on the ground, can become so violent as to result in overturning. In flight, they suppress impulses in power applied to the rotor and, therefore, reduce blade stresses.

Rotors of the Soviet Mi-1 and Mi-4 helicopters are equipped with a dry-friction damper, a type which is no longer used on any USAF helicopter. This damper consists of a stack of steel discs separated by brake-lining material, with alternate discs attached to rotor hub and blade, respectively. The stack is spring-loaded to the desired damping moment. The Mi-4 damper has been made more compact than that on the Mi-6 by using more plates, with smaller diameter, and by locating the spring internally. The dry friction damper has been discarded by most helicopter designers because the damping moment can drop nearly to zero under a sudden high-amplitude blade moment, with resultant violent vibration.

The Mi-6 has adopted the hydraulic damper, the type universally used on USAF helicopters. Damping moment is obtained by restricting the flow of oil through an orifice, and the moment therefore increases with amplitude of blade movement. Damper oil is replenished from a reservoir located on the rotor head, with a separate oil line to each blade damper. Ball-check valves are probably used to prevent flow of the oil from the damper to the reservoir.

In comparing rotor-bearing lubrication practices, it is important to bear in mind that the bearings which permit feathering, flapping, and lagging of helicopter rotor blades are highly loaded and operate continuously in an oscillating motion rather than complete rotation. This is the most difficult operation for any bearing to withstand. Continuous effective lubrication of these bearings is imperative, and is a major rotor-design problem. A free-flowing lubricant is best suited for this purpose, but the difficulty of maintaining adequate seals has led to use of a grease in the bearings of most USAF helicopters.

On the Soviet Mi-1 and Mi-4 helicopters, oil lubrication of these bearings is accomplished through ingenious use of reservoirs to replace lubricant lost through leakage. The flapping and lag hinges are fitted with needle bearings, each of which has an inner bushing serving as an oil reservoir. A spring-loaded piston forces the oil, as it is consumed in operation, into the bearing. These reservoirs are refilled through a lubrication fitting during postflight inspection.

For the pitch-change bearings, which require a greater quantity of oil, a Soviet helicopter-design text recommends the use of a reservoir mounted atop the rotor axis, with individual oil lines to the pitch-change bearing housings. This system is in evidence on the Mi-4 and Mi-6 rotors. When this reservoir must serve the second purpose of replenishing the fluid in hydraulic drag dampers, as appears to be the case on the Mi-6, the reservoir is divided into upper and lower compartments. Hydraulic oil is fed to the dampers from the upper compartment under pressure of a spring-loaded piston as previously described. Lubricating oil from the lower compartment flows to the pitch-change bearings by centrifugal force.

Mounted IL-14 Used to Pare Training Time

◆ The U.S.S.R. has devised a "flight" trainer which simulates in-air operation of all apparatus, and provides for working out special conditions that may occur in flight. For their trainer, the Soviets have used an Il-14 (twin-engine transport) aircraft which has completed its prescribed service life. The aircraft is rigidly mounted but operational in all other respects. The mounting permits the actuation of the landing gear, the simulation of horizontal flight, and the feathering of the propellers with both engines operating.

The trainer is used for both individual and crew training. Pilot, navigator, flight engineer, radio operator, and ground-service personnel all gain experience by this means. Besides training in engine operation and level flight, flight personnel learn to use the auxiliary equipment under such conditions as in-flight icing, fire, and other hazardous circumstances.

The Soviets claim that training in this manner has halved the previous training time and that, in the training process, flight personnel acquire firm habits and uniformity in the technique of piloting.

Pilot and crew training by flight simulators is generally considered to be the most economical, safe, and thorough means of training air crews. Simulators, although costing much less than an operable aircraft, usually call for considerable investment in development time and hardware.

First Experimental Rocket Launched by Polish Scientists

◆ According to Polish newspapers, Poland's first experimental rocket was launched a few months ago. The rocket, intended for meteorological and other studies, was launched at an angle of 80 deg. from a 3-m. launcher, the report says. The Krakow Branch of the Polish Aeronautical Society and the Department of Rockets of the Krakow Academy of Mining and Metallurgy are mentioned as the designers.

Announced specifications of the rocket are: length, 820 mm.; diameter, 63 mm.; weight, 4.35 kg.; weight of the solid fuel, 1 kg.; working pressure, 40 kg. per square centimeter; and thrust, 100 kg.

Nonductile Materials Forged in U.S.S.R. Process

◆ One of the results of concerted U.S.S.R. research on the behavior of metals under pressure is Soviet development of a process called "back pressure forging." Details of the process have not been publicized, but, in general, it consists of subjecting the billet to very high compressive stresses from all directions prior to, and during, the forging action. In this manner, normally nonductile materials can be forged which otherwise would crack or tear. By the new method, the Soviets have made experimental forgings of such nondeformable material as marble. While early development was conducted primarily on simple shapes, by 1956 the Soviets were applying the information to solving production problems on complex shapes.

If successful, the latter application would serve extensively, of course, in airframe, engine, and missile production where many of the desirable materials are of low ductility and difficult to deform.

What Lockheed is doing today to develop

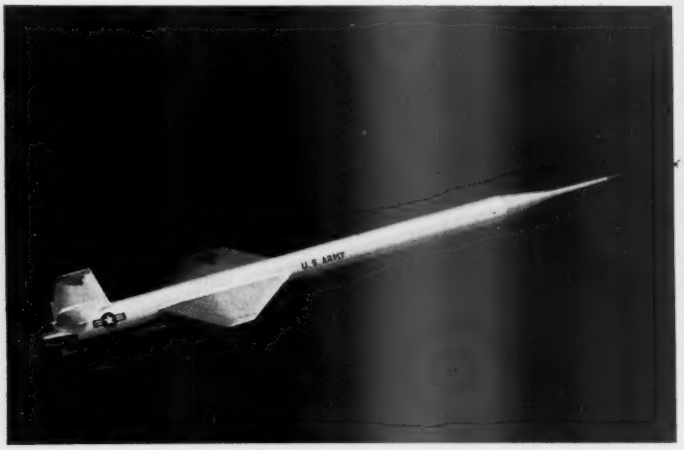
Tomorrow's missiles and spacecraft

The world's first polar-orbiting satellites...the world's fastest ramjet target drone...a "fuel cell" that produces auxiliary power for spacecraft in a radically different way...a TV camera-transmitter—the world's smallest—that gives engineers and scientists on the ground a televised report of what takes place in test missiles during flight. These are just a few of the many activities and achievements of Lockheed's Missiles and Space Division.

Lockheed is System Manager and Prime Contractor of the ARPA DISCOVERER satellite series—and the U. S. Navy's POLARIS missile. Both are highest priority programs of the U. S. Government. And both are ahead of schedule.

A Lockheed MSD work-force of over 16,000—including 3,500 scientists and engineers—is engaged in all phases of missile and space technology: satellite systems development; space communications; electronics; ionic, nuclear, and solar propulsion; magnetohydrodynamics; computer research and development; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation—and many other advanced fields.

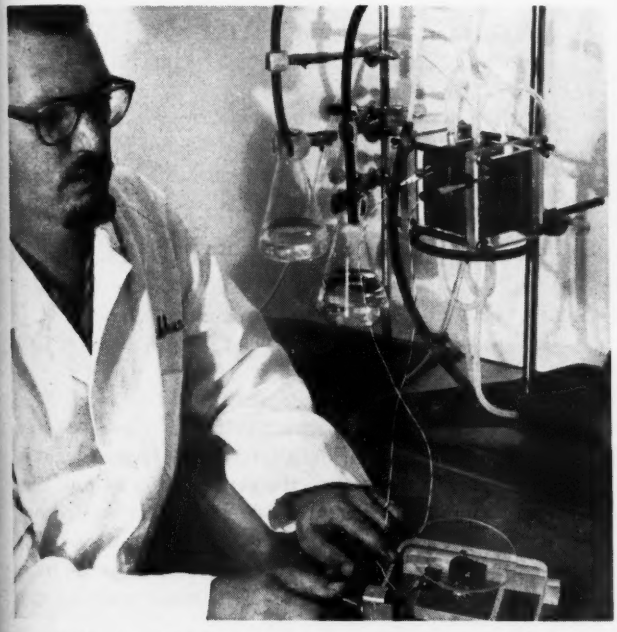
From these efforts at Lockheed will come many significant breakthroughs and scientific "firsts"—to speed the development of tomorrow's missiles and spacecraft.



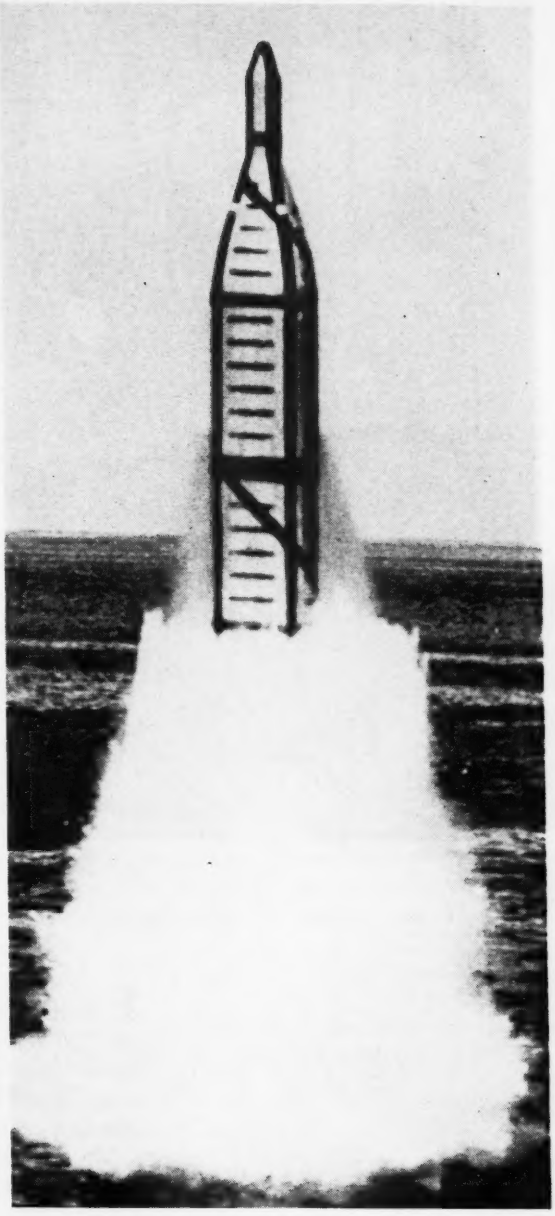
Ramjet-powered supersonic target, Lockheed Q-5 KINGFISHER electronically simulates enemy attackers—is being used by U. S. Army to evaluate and sharpen our nation's missile marksmanship, increase our defense capabilities.

First polar-orbiting satellites, the Lockheed-built DISCOVERER I and II were orbited in two successive launches. Lockheed is System Manager for this ARPA advanced scientific research program.

Transmitting performance data from missiles and test vehicles, direct to ground stations, Lockheed-developed TV camera-transmitter and PAM-FM telemetry systems are acknowledged to be the world's smallest, world's best.



Revolutionary "fuel cell," under development at Lockheed, converts chemical energy directly into electrical power—for auxiliary power requirements of miniaturized spacecraft instrumentation and space communications systems.



Erupting from beneath the sea, a full-scale POLARIS test vehicle demonstrates how operational missile will be launched from submerged U.S. Navy subs. Ultimate range of the POLARIS will be 1500 nautical miles.

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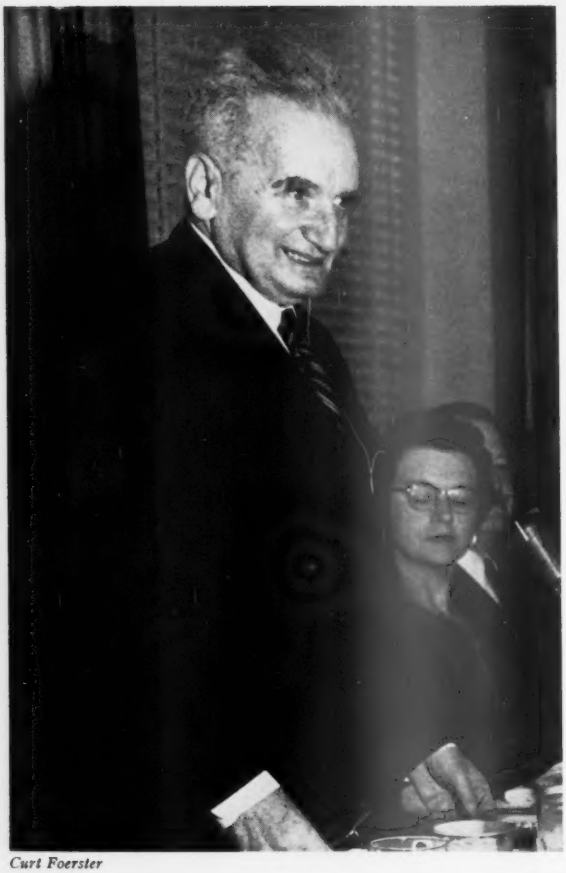

Curt Foerster

GUEST EDITORIAL

A few

"VON KÁRMÁNISMS"

Excerpts from a talk given by Dr. Theodore von Kármán at Cornell University on April 4th on the occasion of the 1959 Northeast Student Conference of the IAS.

Engineering Education was always an important subject. First we may ask: What is the definition of Engineering Education? I read once that it is transferring the experience of one generation to the next. I don't think this really covers the whole meaning of Engineering Education. It was recognized very early that the transmission of experience is not sufficient.

The great British engineer Rankine said, "A Practical Engineer is the man who perpetuates the mistakes of his predecessors!" I don't want to say anything against the Practical Engineer, but Rankine was among the first who thought that the transmission of empirical data, the transmission of empirical knowledge, is not sufficient.

You cannot say anything against empirical data. Empirical data and empirical rules are very important. However, we must know exactly for which cases we want empirical data and in which domain they can be employed.

✦ ✦ ✦

Some people say an engineer is a scientist. I don't think that is quite correct. Engineering Education is not to educate only scientists. After all, the engineer is a man who creates not only ideas, not only theories, but also bridges, machines, airplanes—what we in the aeronautical industry call "hardware." And his purpose is to create hardware. So we should not underestimate his faculty and his talent for design. Unfortunately, I believe that talent for design is more or less something you bring with you. You can develop and you can improve, but it is something you must be born with.

Today we cannot design only from intuition. The engineering student, in addition to his ability to design something, must understand more than the fundamentals of natural sciences. If he is producing hardware, if he is producing machines, and, doing so, works with materials, he *must* understand fundamentals of natural sciences. But I believe that if he wants to become an executive, if he is interested in sales, if he is interested in practical problems, he should also understand the fundamentals of *social* sciences. I think this very important.

✦ ✦ ✦

In aeronautical engineering the student is in a very fortunate position because he is able at the same time to follow technical progress, practical progress, and the progress of science. There is one great difficulty in aeronautical engineering: The field becomes larger and larger. When we started Aerodynamics, we used an approximation considering air an incompressible fluid, like water. And it was rather easy to solve some of the fundamental problems. Then, as the velocities increased and we came in the transonic region, an understanding of Thermodynamics became necessary.... So Aerodynamics became much more complicated with Thermodynamics added.

Fortunately, at the time we did not have much to do with chemistry. We had chemical problems in engines, of course. Every engine company had a chemist, a specialist who knew what "anti-knock" was, and that was sufficient! But after the piston engine was replaced by the jet, this was not good enough because we now find that you cannot separate flow phenomena from the chemistry. As the hypersonic velocities came with the missiles, we had to deal with chemical reactions which we did not want. After all, the chemical reaction necessary to burn kerosene is something you definitely want and plan for. But, if you have a missile and it enters the dense atmosphere and you have high-temperature dissociation and recombination, then you have reactions which you don't want. Nature produces them and you have to understand them....As we became interested in space and in new methods of propulsion it turned out that chemistry was not enough. We needed also Electromagnetism. Cornell University is one of the centers where this new branch of aerodynamics—which we call magneto-hydrodynamics —is successfully cultivated.

✦ ✦ ✦

So you can see the aeronautical engineer must today be interested in all these neighboring sciences, not only physics, thermodynamics, mechanics, but also chemistry, electromagnetic theory, and electromagnetic phenomena.

I gave as the title of this little talk "Engineering Education in Our Age." I did not want to say "Engineering Education in the Space Age" because I don't want to overemphasize that aspect of our progress.

"Space" has created, I would say, something of a panic in industry, maybe also in science. I am glad the Institute took up the name Aero/Space and Aero/-Space Sciences, but on the other hand I don't think we can say Aeronautical Science is finished and Aero/-Space Science started. Actually, it is only an extension: We have new limits of speed and new concepts of altitude. But that is natural....

So I do not believe there is any reason to say Aerodynamics is obsolete. There is no reason to say, "I am an airplane designer, and what shall I do? Nobody wants airplanes."

First, for some years we'll need airplanes. Second, the problems we have in airplane design we have also in missile design, and in the design of any other air or space vehicle. It would be a miracle if we could make vehicles for space or vehicles for upper atmosphere and not encounter the same problems—buckling, flutter, and so on—that we have in airplane design.

So, my young friends, I recommend that you look at this problem from a very broad point of view, and don't believe that everything you learn and everything that is in the books is now obsolete and that The New Age, The New Science starts. Science, I think is eternal. It started many thousand years ago and is a continuous process. I hope that we older people will see from the other side of Space what your generation will develop along the same line that we started to teach you.

T.vK.

"The development program for acoustically loaded structure for the DC-8 jet transport [is] described . . . . New techniques of experimental stress analysis, using a high-intensity siren, [are] outlined."

Development of Aircraft Structure to Withstand Acoustic Loads

Peter M. Belcher, Joseph D. VanDyke, Jr., and Arthur L. Eshleman, Jr., MIAS

Douglas Aircraft Company, Inc.

THE DEVELOPMENT of structure adequate to sustain high acoustic loads is of great importance to airframe design. Although considerable engineering effort and, in a few instances, prodigious expenditures have been devoted to the solution of this problem for individual aircraft, no rational, economical design method has appeared. The authors propose the techniques employed in the design of the DC-8 jet transport to answer this need.

This paper describes the development program from design requirements, through analysis and laboratory investigation, to proof test of production assemblies for acoustically loaded structure for the DC-8. Although the discussion relates directly to the DC-8, the principles and results are applicable to airframes in general.

The Design Problem

When the layout of control-surface structure for the DC-8 was begun, the treatment of acoustic loads was a design consideration for which no adequate procedure existed. The scattered information from previous designs of Douglas Aircraft Company and its industry associates was thought to be of little value beyond its clear implication that the problem required consideration. Our opinion persists that the sporadic data of service experience, when they incorporate inaccuracies in the record of time and load and are averaged over structural designs of varying detail quality, are of negligible value in initial design. Further, it appeared that convergence on near-optimum design by test and redesign of major assemblies, within reasonable time and cost limits, was unlikely. What was desirable, of course, was a unified program wherein the testing of successively more complex assemblies was accompanied by a systematic analysis of the loads, the responses to these loads, and the fatigue accumulation of the parts undergoing these responses.

The Phenomenon

There is little mystery about the phenomenological fatigue behavior of a structural component. Under an oscillatory load, the part responds in vibration with associated stress alternations. The relationship between this stress and the number of cycles to failure is known, within reasonably well-established scatter, for materials commonly used to carry structural loads. However, for the problem considered here the critical stress can be difficult to measure, for it often occurs at corners or joints where strain gages cannot be satisfactorily placed. Therefore, an important advantage of the high-intensity-siren techniques described in this paper is that a great deal may be learned about the structure's load-carrying properties with no more than the inferential knowledge of stress magnitudes available from the occurrence of failure.

In common with other development programs for fatigue resistance, two broad areas of effort were required:

(1) To improve the details of each structural type, with the intention of attaining near-optimum load-carrying ability per unit weight.

(2) To then determine the load-carrying ability of each structural type.

The Siren: Initial Tests

When the Douglas high-intensity-siren test facility[1, 2] became available for use early in 1957, a program was undertaken to investigate problems (1) and (2) of the previous section, using 24-in.sq. panels.

Refinement of the bead termination of beaded-inner-skin structure resulted in the occurrence of failure at the center of a bead span as often as at the ends. This revised configuration, no heavier than the original, lasted as many cycles as the original at a 6-db higher load.

Mr. Belcher was awarded the degrees of Bachelor of Science and Master of Science in the physical sciences and mathematics by the University of Michigan. He is a member of the Acoustical Society of America. As assistant to the Supervisor of Research and Development within the Acoustics Section of the Douglas Aircraft Company's Santa Monica Division, he directed the Section's development work on acoustically excited structural vibration and fatigue and was responsible for research concerning the transmission of sound through structure. Mr. Belcher is now with North American Aviation, Inc., Inglewood, Calif.

Mr. VanDyke received his B.S.M.E. degree from West Virginia University in 1951. Since then he has been employed by the Douglas Aircraft Company's Santa Monica Division in the Engineering Structures Design Section. He has participated in the structural design of the DC-6A, DC-6B, DC-7, C-133A, and DC-8 airplanes and has been in charge of the design and test work done by the Structures Section on acoustically loaded structure for the DC-8.

Mr. Eshleman is an engineering graduate of the University of California at Los Angeles, and is a member of the Institute of the Aeronautical Sciences. He joined the Douglas Aircraft Company in 1939 and has been in the Engineering Structures Design Section, Santa Monica Division, since 1940. He has participated in the design of 15 Douglas aircraft, including commercial and military transports and Air Force bombers and research aircraft, and has directed the empennage design of the C-133A and the DC-8. He is in a large measure responsible for the modern structural techniques used in Douglas control surface designs.

Corner design, terminations, and attachments of honeycomb-sandwich panels were improved to avoid premature failures at these details.

Bonded scalloped skin-doublers at the rib supports were developed for skin and rib combinations so that rivet holes, with their stress concentrations, are no longer the locations of highest stress. Use of the doubler results in a significant reduction in weight, for the skin and doubler combination will carry slightly more load than a plain skin whose gage equals the thickness of the combination.

Tests on these skin and rib panels confirmed the expectation that replacement of bent-flange rib-caps by extruded T-section rib-caps greatly increases the load-carrying ability of the rib, for the extrusion provides more material in the bend radius and compels a more symmetrical reception of load from the skin.

Load and Fatigue Analyses

Coincident with these early tests, two analyses were undertaken:

(1) Acoustic loads on the structure were determined by extrapolation of near-field noise data of engines comparable in thrust to those of the DC-8.

(2) The relationships among load, response, and fatigue for both jet and sinusoidal loading were investigated theoretically.[3]

Determination of Loads

Techniques for velocity and exit-area correction of available jet-engine noise data, including a velocity correction for the increase of thrust due to water injection, were reasonably well established. Thus, load contours, exemplified by Fig. 1, could be developed. Since a jet-noise suppressor was to be included in the DC-8 configuration, reductions of the computed loads were introduced on the basis of information obtained in model-scale development tests of the suppressor.

Response Analysis

Analytical approaches to the problem of random acoustic excitation of structure were offered in 1954 and 1955, respectively, by Miles[4] and Powell.[5] The method herein described is a modification of Miles' treatment of the linear one degree of freedom system idealization in response to a random force.

At resonance the mean-square stress response $\overline{s_r^2}$ of a linear single degree of freedom system—having resonance frequency f_0, damping δ (fraction of critical damping), and stress response to unit static load s_0—to a random force of spectral density p_r^2 (rms sound pressure squared in a 1-cps bandwidth) is[2]

$$\overline{s_r^2} = (\pi/4\delta) f_0 s_0^2 p_r^2 \qquad (1)$$

Similarly, for sinusoidal excitation,

$$s_s^2 = (1/2\delta)^2 s_0^2 p_s^2 \qquad (2)$$

where p_s is the rms sinusoidal excitation pressure. Elimination of s_0 yields

$$\overline{s_r^2}/s_s^2 = \pi f_0 \delta (p_r^2/p_s^2) \qquad (3)$$

Cumulative Damage and a Random-Load s-N Curve

Miles[4] showed that, if the stress peaks are assumed to be distributed according to the Rayleigh probability density $P(s)$ and if Miner's hypothesis of cumulative damage[6] is assumed, a relationship between random stress and fatigue damage can be determined. From Miner:

$$D_s = n_s/N_s \qquad (\textstyle\sum D_s = 1 \text{ at failure}) \qquad (4)$$

where D_s is the proportion of damage related to stress

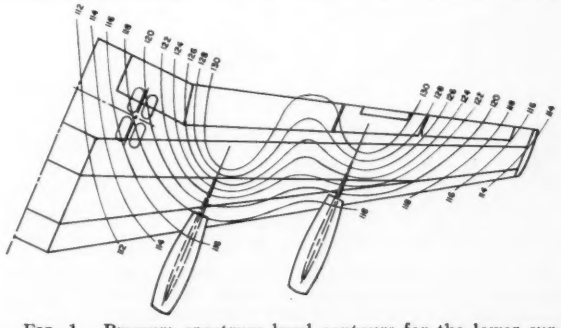

FIG. 1. Pressure spectrum level contours for the lower surface of the DC-8 wing at 400 cps, for an unsuppressed JT3C-6 engine at take-off thrust.

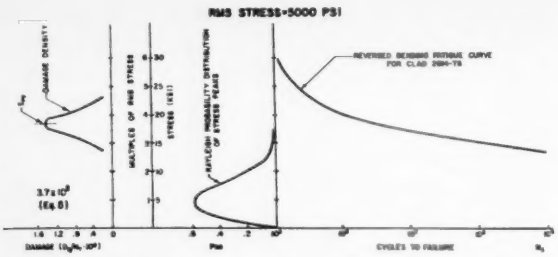

FIG. 2. Damage density computation [Eq. (6)] for clad 2014-T6 alloy at an rms stress of 5,000 psi.

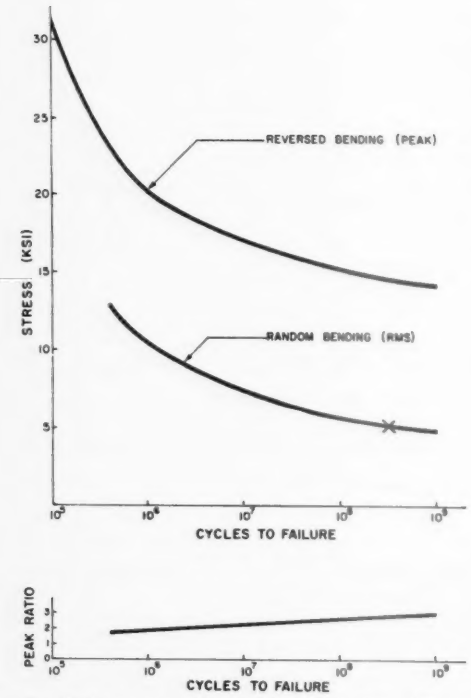

FIG. 3. Fatigue curves for clad 2014-T6 alloy. The random bending curve was computed using Eq. (8). The peak ratio is the quotient of the ordinates at each N. The "X" corresponds to the point computed from Fig. 2.

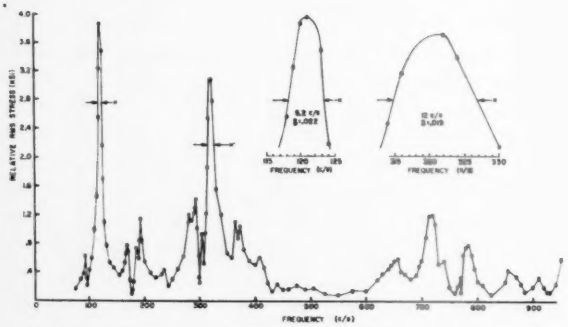

FIG. 4. Frequency-response curve read from a gage located on the skin of a beaded-inner-skin panel. The fundamental-frequency pressure level was 143 db.

peaks (peak-to-peak reversals) of the level s, n_s is the number of stress peaks of level s, and N_s is the number of stress peaks of level s necessary to cause failure (as expressed by an s-N curve). Now, if N_T is the total number of cycles to failure and $P(s)$ is the fraction of cycles occurring at the stress level s, then $N_T \cdot P(s)$ is the number of cycles at the stress level s. But this is n_s:

$$n_s = N_T \cdot P(s) \tag{5}$$

Therefore,
$$D_s = [N_T \cdot P(s)]/N_s \tag{6}$$

is the desired relation. Fig. 2 indicates[2] that, for rms stress levels low enough to result in long life, the damage is done by only a very few of the stress reversals, perhaps fewer than 2 per cent, and that these stresses are of high magnitude, averaging over three times the rms value.

It is here that a practical solution diverges from that of Miles,[4] which approximates s-N data by a linear log s-log N curve. His approximation is highly conservative if, for example, the line is arranged to coincide with data from $N = 10^6$ to 10^9. The use of values for N_s from actual s-N curves for the materials and numerical integration over the continuous distribution of stress magnitudes leads to a more realistic solution:

$$1 = \int_0^\infty D_s ds = N_T \int_0^\infty [P(s)/N_s]\, ds \tag{7}$$

Thus,
$$N_T = 1 \Big/ \int_0^\infty [P(s)/N_s]\, ds \tag{8}$$

Evaluation of the integral for various values of rms stress yields an s-N curve for random stress[3] corresponding to the original s-N curve for stresses of discrete amplitude (Fig. 3). The ratio of the discrete-stress level to random-stress level at each N may be regarded as a peak factor for the random response. Fig. 3 indicates the dependence of this factor on the fatigue life.

Panel Response Data

Frequency-response explorations of panels, using the siren as excitation source and strain gages as response-sensing devices, yielded information about modal resonance frequencies, damping constants, and the relative magnitudes of stress associated with the various modes contributing to deformation at the gage locations. Stress-response vs. load curves for the various resonances showed, in general, nonlinear relationships when the load magnitude corresponded to the level at which the fatigue test would be run. Correction factors for Eq. (3) were developed for the contribution of multiple modes to the rms stress under jet loading and for the nonlinear stress-load behavior of the panel. (More will be said about these two corrections in the section entitled "Some Technical Considerations.") Eq. (3), with these factors included, becomes

$$\overline{s_r^2}/s_s^2 = \pi f_0 \delta (p_r^2/p_s^2) \lambda \gamma \tag{9}$$

Random-Sinusoidal Load Equivalence

Eq. (9), a relationship of panel parameters which are derivable from the siren frequency-response and stress-load curves (e.g., Figs. 4 and 5)[7] and the random-load s-N curve for the material, provides a means of calculating allowable random loads on the airplane from siren fatigue information. This equation was plotted in the form of a nomograph[8] which provides a rapid computation of siren pressure and the related number of test cycles or time to proof test a part for a known load condition on the airplane.

A Tentative Design Chart

With a J-71 jet engine as a random-noise generating device, a limited number of fatigue failures were obtained in tests of box-type skin and rib constructions similar to those used in the siren tests. A tentative design curve for this structural type was constructed, extrapolating from these test points by use of the rule that the bending stress at the support of a long panel is proportional to the square of the ratio of panel width to panel thickness. The curve, in depending on this stress relation, assumes that f_0/δ is approximately constant for panels of various widths and thicknesses. Although this assumption cannot be verified from the limited data available, the approximation is provisionally acceptable since the fatigue data fit the assumed stress dependence within the scatter of s-N data. Failure data from siren tests, converted by the sinusoidal-random conversion nomograph, were entered on the chart and found to show similar agreement.

Fig. 6 is the chart for skins without doublers. It also shows approximate required gages for bent-flange ribs, as well as approximate resonance frequencies for the fundamental mode of vibration of the individual skin panels. Curves for other structural types and for skin-rib constructions with scalloped doublers can also be drawn.

Structural Design and Tests of Assemblies

With this knowledge it was possible to decide on the types of structure to be used for areas of high acoustic load on the airframe. For the flaps and ailerons, a design optimization study for nonacoustic loads showed that the greatest strength-weight efficiency could be obtained by use of a rib spacing of 4–5 in. This matched the requirement for acoustic load (see Fig. 6), for with 4-in. rib-spacing no increase in skin or doubler gage was necessary. The ribs, in general, had to be one gage above that required in the absence of acoustic loads. A similar configuration, with wider rib spacing corresponding to the lower acoustic loads, was chosen for the elevators and rudder. Beaded-inner-skin construction was selected for the large spans of the vertical and horizontal stabilizers which carry, primarily, aerodynamic and acoustic loads. The wing trailing-edge upper and lower surfaces are, respectively, closely spaced stringers and skin, and $^1/_2$-in.-thick honeycomb-sandwich panels supported at an average of 15 in. The landing-gear door panels are of skin and rib construction. The wing to fuselage fillet utilizes large-span honeycomb panels, as do the fiberglass structures used as antenna mounts.

Tests of Structural Assemblies

Siren tests of 5-ft.-long assemblies of the wing trailing-edge, flap, and aileron structure were then conducted. The fatigue performance of the individual panels of these assemblies repeated that of the similar 24-in.sq. panels. Examples of modifications introduced as a result of these tests include the addition of a T-stiffener to the wing trailing-edge ribs (Fig. 7) to alleviate rib-flange stresses and an increase in the web depth of the flap nose-ribs to make them twice as stiff as they were originally.

Jet-Loading Test of Production Structure

Although a remarkable self-consistency had characterized the siren test results, no adequate demonstration of their correlation with fatigue behavior under a random load had been made. Further, the laboratory tests of idealizations of the airframe parts left questions about some details of the production structure. It was

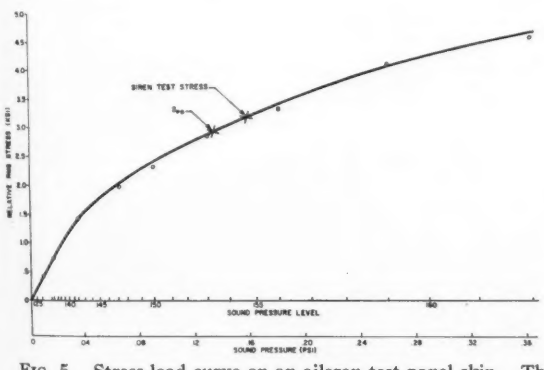

FIG. 5. Stress-load curve on an aileron test-panel skin. The difference between the siren test stress and peak damage stress was less than 1 db. for the fatigue test of this panel.

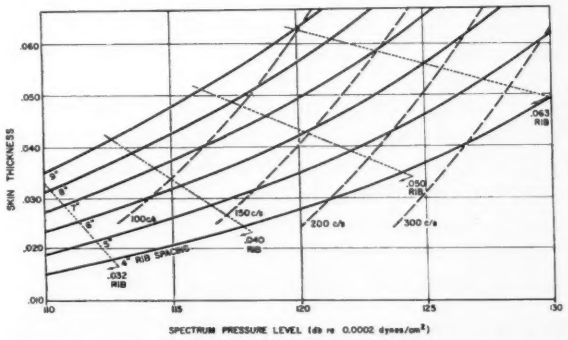

FIG. 6. Tentative design chart for rib and skin structure with bent-flange ribs and without skin doublers, for a design life of 10^9 vibration cycles under jet-noise load. Required rib-gage curves and curves for the fundamental resonance frequency of the skin panels are superimposed. The alloy is clad 2014-T6.

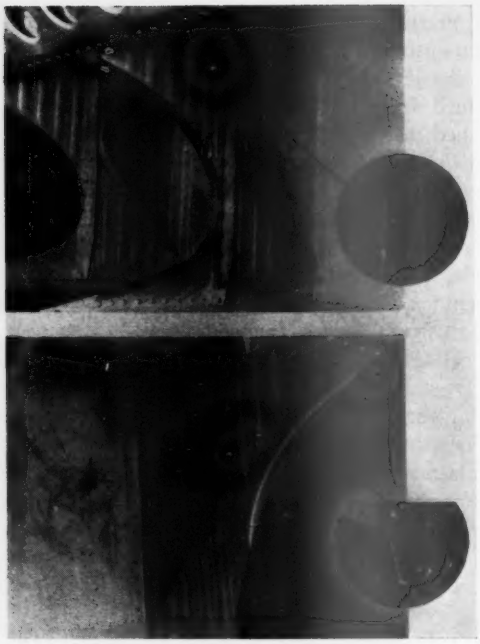

FIG. 7. Wing trailing-edge ribs of the siren test specimen. "Stress coat" cracks show high stresses in the T-section stiffener (*above*) and in the cruciform clip (*below*).

decided to investigate these problems in a series of tests on production parts.

A dummy wing was incorporated with the structure of the thrust stand on which a JT3C-4 (J-57) engine was being run for noise suppressor-reverser tests. To this were added 18-ft.-long sections of production wing trailing edge and flap (Fig. 8). These parts were complete in detail, including the removable sections, vane, and engine exhaust-gate of the airframe flap installation.

Temperature, exhaust pressure, and acoustic pressure data were taken with the engine at various thrust settings and with the flap at the faired, take-off, and landing positions.

A fatigue life test was then undertaken in four phases:

(1) The engine was run a total of 3 hours at water injection take-off thrust with a mixer-ejector suppressor installed. This device is acoustically similar to the type to be used on the production airplane. Complete tear-downs and inspections were undertaken after $1^1/_2$ and 3 hours.

(2) The ejector was removed, and $1^1/_2$ hours were accumulated with the same mixer suppressor installed. Again a complete inspection was undertaken.

(3) The engine was then run at dry take-off thrust with no suppressor for 15 min.

(4) Following inspection, the engine was run at wet take-off thrust with no suppressor for 15 min.

Structural Performance

No failure of load-bearing structure occurred during the four phases of the test. During a wet take-off engine run shortly thereafter, four rivets tying skin to ribs on the flap failed. During phase (1) the 0.025-in.-thick sheet-metal trailing edge (aft 3.5 in. of the surface) which terminates the flap exhaust-gate developed cracks. This was repaired, but more cracks developed during a later phase of the test and further repair was necessary. During phase (3) the trailing edge on the flap proper, where the temperature is lower than on the gate, developed cracks. This part similarly required repeated repair. This fairing had been judged to be inadequate in the siren tests and a revision had been specified for the airplane.

Accelerated-Test Interpretation

The accelerated nature of this test is interpreted here in terms of the skin panels of the flap. If it is assumed that the design life of this part is 10^9 cycles of stress reversal at take-off thrust with the mixer-ejector suppressor installed on the engine, then the rms stress at which the part works should be no higher than 4,250 psi, as indicated by Fig. 9. The bar at this stress level corresponds in number of cycles to the 3-hour test of phase (1). Similarly, bars for phases (2), (3), and (4) have been drawn. The increases in stress from phase (1) are less than the corresponding increases in sound pressure by amounts computed from the nonlinearity of the stress-load response, known from siren data for similar skin panels. The fraction of total damage accumulated under each item has been computed using Eq. (4) and is indicated on the figure. The JT3C-6 engine used on the airplane, running on a standard day, has increased sound levels and associated increases in stress which can be accounted for by requiring that the stresses of phases (1) through (4) be proportionally lower during the JT3C-4 engine test. The revised position of the bar for phase (4) is indicated by the dotted line of Fig. 9.

If the assumptions on which this computation depends are valid, the part has been qualified for the JT3C-6 engine by a margin in stress in excess of 1 db. While it is true that this margin is comparable to the scatter of s-N data, it must be remembered that the

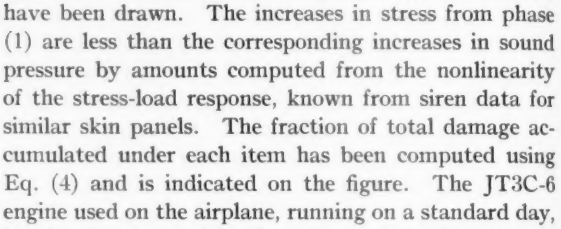

FIG. 8. Wing trailing-edge and flap specimens mounted on the engine test stand.

test was complete before a failure of significance occurred.

The use of engine-noise suppressors on the DC-8 resulted in somewhat lighter structure than would have been necessary for unsuppressed engines, and also made an accelerated fatigue test convenient. It should be strongly emphasized, however, that this design method is suitable for structure loaded by the noise of unsuppressed engines or, for that matter, of engines generating much greater sound pressures. The nature of changes which would have to be made in a skin and rib configuration for these higher load conditions can be determined from Fig. 9.

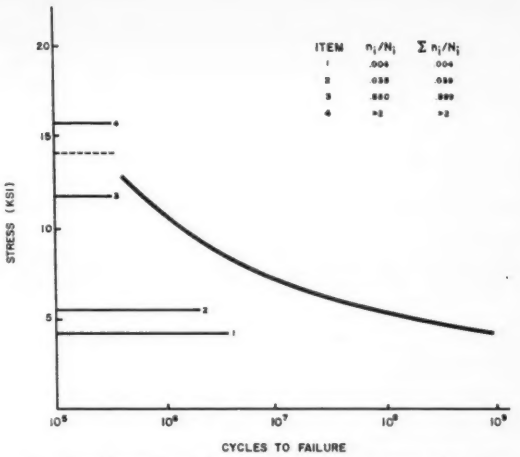

FIG. 9. Fatigue-accumulation chart for a flap skin in the test of production structure. The alloy is clad 2024-T3.

Some Technical Considerations

Nonlinear Panel Response

The nonlinear character of riveted skin structures, even at moderate stress levels, is well known. Eq. (9) includes the factor λ to account in part for the role of panel nonlinearity in the sinusoidal-random excitation conversion. A more accurate correction would take into account the distortion of the distribution of stress peaks which the "stress suppression" behavior of nonlinearity produces. Failure to account for this distortion results in a conservative test.

It may appear at first consideration that a nonlinear part, which is subjected to an accelerated test to qualify it for long life performance, would be tested at a stress level much greater than that at which the airframe part is to perform. Fig. 2, however, implies that this is not so. A part which lasts 10^9 stress cycles under random load will experience only about 2 per cent (on the order of 10^7) as many cycles which actually do appreciable damage. In the siren test, if the part has a 400-cps principal resonance and is tested at a sound level which produces failure in 30 to 60 min. (order of 10^6 cycles), the effective working stress levels (Fig. 3) for the two conditions are only about 15 per cent different (20,000/17,000 = 1.17). A more striking example of this working-stress/test-stress similarity is shown in Fig. 5, where the difference is only 8 per cent.

The factor λ is used to correct for the difference in stress per unit load, usually small, between these two stress levels:

$$\lambda \simeq (\alpha_{PD}/\alpha_T)^2 \qquad (10)$$

where α_{PD} is the stress per unit load at s_{PD}, and α_T is the stress per unit load at the siren test level; s_{PD} ("peak damage stress") is defined as the stress at which the greatest amount of damage occurs during vibration under random load (see Fig. 2).

Multiple-Mode Response Under Random Load

The siren, which produces discrete-frequency sound in which the fundamental strongly predominates, excites the test panel at only one resonance at a time. Fig. 4, a frequency-response curve produced at constant excitation pressure, shows the multiple-modal character typical of most structural components. The relative stress magnitudes of Fig. 4 are by no means unique, however, for the placement and orientation of the strain gage permits sensing of the relative modal contributions only at one small area and only in the direction in which the gage is sensitive. Only if the gage is placed where failure ultimately occurs and if the gage direction is the principal stress direction for the dominant mode at this point (if one mode is dominant!) can we say that the relative magnitudes of Fig. 4 are quantitatively meaningful. Further, the relative stresses generally depend on the angle of incidence and the direction of propagation of the sound.

A part under the random load of jet-engine noise responds in the same modes as under siren load, but little can be said with certainty of the relative magnitudes of response of these modes and of their contribution to failure. However, narrow-band analyses of strain-gage outputs from parts under random load often show qualitative relationships among stresses from the various modes similar to those of the corresponding siren-excitation response curves.

One technique which has been helpful in this respect involves the siren excitation of a part to which has been applied a strain-sensitive lacquer (see Fig. 7). The pattern which appears in the lacquer when the part flexes indicates the location and direction of high stresses. Usually, if the part is of good detail design, these locations will be in areas where the stress gradient can be readily seen. Thus, strain gages can be advantageously placed. Even with the use of this technique, however, it is probable that the greatest errors in the sinusoidal-random equivalence computation arise in the interpretation of multiple-mode data.

The factor γ of Eq. (9) is defined as

$$\gamma = \overline{s_T^2}/\overline{s_i^2} \qquad (11)$$

where $\overline{s_i^2}$ and $\overline{s_T^2}$ are, respectively, the mean-square stress arising in the mode under consideration and the total mean-square stress response of all the modes. For modes well separated in frequency[8]

$$\overline{s_T^2} \simeq \overline{s_1^2} + \overline{s_2^2} + \ldots = \sum_{i=1}^{n} \overline{s_i^2} \qquad (12)$$

From Eq. (3)

$$\overline{s_i^2} \sim \pi \delta_i f_i p_i^2 s_{si}^2 \qquad (p_s \text{ constant}) \qquad (13)$$

where the subscript r (random) has been suppressed. Thus,

$$\gamma = (\sum \delta_i f_i p_i^2 s_{si}^2)/(\delta_i f_i p_i^2 s_{si}^2) \qquad (14)$$

This correction must be applied in the computation of the test level for each mode.

Note should be made of the ease with which accurate frequency-response curves can be produced by use of a siren test-facility in which a plane progressive wave propagates in the direction parallel to the face of the panel and is terminated in such a way as to avoid standing waves. One would expect that "normal incidence" sirens, some of which are now in use, would entail great difficulties in this respect because of the extreme frequency sensitivity of standing wave systems. A price is paid for the convenience of the parallel incidence arrangement, however, for the absence of the pressure multiplying effect of standing waves must be compensated by greater air-source capacity.

Correlation and Wavelength Considerations

Present limited knowledge does not allow quantitative inclusion of pressure correlation and excitation wavelength effects in practical stress-response computations. Often the alternative is conservative design. However, the exciting pressure field is well correlated over distances short with respect to a wavelength. Fortunately in this respect, most structural areas of the DC-8 for which acoustic loads are critical utilize small-span panels.[8]

Adequacy of the Test Specimen

The utility of the basic 24-in.sq. panels arises in that they are inexpensive and can be constructed quickly. Thus, economical tests of numerous configurations are possible. Further, each has a well-defined, idealized configuration, leading to simplification in the interpretation of test results.

Use of the basic specimen requires justification, however, for, if care is not taken, the response of its individual panels will depend on the specimen edge-details and on the method of attachment to the test fixture. In the case of specimens whose individual panels have semirigid supports, for example, attention during the test is confined to the center bay or bays where the specimen edge-effects are minimal.

Although the basic panels often have the limitation that they simulate the actual structure accurately only near the center of the panel, the 5-ft.-long constant-section specimens, comprising a spanwise arrangement of a larger number of bays of panels, provide an accurate simulation of coupling effects. Moreover, the 5-ft. specimens include spar webs and caps, closing channels, etc., and thus provide for the testing of attachment details.

Combined Loading Conditions

Although the effect of simultaneously applied acoustic loads and loads of other origin has to be considered in each individual case, the combined loading condition is critical in very few instances for the DC-8 structure. For example, the flap experiences high acoustic load during the take-off roll. However, as the air load increases with increase in speed, the velocity of the jet relative to the airstream decreases and, therefore, so does the acoustic load.

Conclusion

The development program for acoustically loaded structure for the DC-8 jet transport has been described. A summary of the analysis and test phases and their interrelationships has been given. New techniques of experimental stress analysis, using a high-intensity siren, have been outlined. The results of the siren test program, used in the design of the airframe structure, have been shown to be verified by accelerated tests of production structure under jet-noise loading.

The results of the program inspire confidence that a method of relatively inexpensive structural development has been established. With the requisite background of information and experience, airframe manufacturers can solve new design problems with comparatively little development cost and lead time.

References

[1] Belcher, P. M., *Use of a High Intensity Siren in the Fatigue Testing of Structures Subjected to Acoustic Forcing*, J. Acoust. Soc. Am., Vol. 29, No. 1, p. 176 (A), Jan., 1957.

[2] Belcher, P. M., *The High Intensity Siren as an Instrument for Fatigue Testing of Aircraft Structure*, High Intensity Acoustical Test Facilities, Loud Speakers and Sirens, Ed. by Jackman, K. R., pp. 15–27; Convair, Pomona, Calif., 1957. (The paper was presented at a Los Angeles Section Specialists Meeting, IAS, Feb. 26, 1957.)

[3] VanDyke, J. D., Eshleman, A. L., and Belcher, P. M., *A Method for Designing and Testing Structures Subjected to Random Acoustic Loading*, Douglas Aircraft Co., Report No. SM-22555, Aug., 1956.

[4] Miles, J. W., *On Structural Fatigue Under Random Loading*, Journal of the Aeronautical Sciences, Vol. 21, No. 11, pp. 753–762, Nov., 1954.

[5] Powell, A., *On the Fatigue Failure of Structures due to Vibrations Excited by Random Pressure Fields*, J. Acoust. Soc Am., Vol. 30, No. 12, pp. 1130–1135, Dec., 1958.

[6] Miner, M. A., *Cumulative Damage in Fatigue*, J. Appl. Mech., Vol. 12, No. 3, pp. 159–164, Sept., 1945.

[7] Rader, W. P., Belcher, P. M., VanDyke, J. D., and Eshleman, A. L., *Load Computations Used in Acoustical Fatigue Tests of DC-8 Structure*, Douglas Aircraft Co., Report No. SM-23234, Nov., 1958.

[8] Powell, A., *On the Response of Structures to Random Pressures and to Jet Noise in Particular*, Random Vibration, Ed. by Crandall, Stephen H., Chap. 8; The Technology Press, Cambridge, 1958.

". . .to examine some of the problems that arise in the interaction between the guidance and propulsion essential for the optimum performance of a system designed to fulfill a photographic graze mission in near interplanetary space."

Trade-Off Considerations in the Design of

Guidance Equipment for Space Flight

Charles J. Mundo, Jr.
American Bosch Arma Corporation

EXTENSIVE CONSIDERATION has been given to the optimization of individual parameters involved in space flight systems, such as propulsion, guidance, trajectories, and structures. Unfortunately, much less thought has been given to the equally important consideration of how these fundamental parameters can be integrated in an optimum manner. The difficulties encountered in meeting even the simplest objectives in the space sciences make it imperative that a careful balance of these design parameters be utilized in synthesizing systems for space flight. It is the objective of this paper to examine some of the problems that arise in the interaction between the guidance and propulsion essential for the optimum preformance of a system designed to fulfill a photographic graze mission in near interplanetary space. This interplanetary mission can be accomplished on the basis of either a continuously propelled system with homing type of guidance or the use of equipment which will establish the vehicle on a ballistic glide to its destination. The former is relatively inefficient in terms of fuel consumption and, therefore, should not be considered until high specific impulse engines become available. This latter type of system reflects many of the difficulties into the design of the guidance equipment, and establishes requirements in terms of both guidance measurements and knowledge of the dimensional and gravitational constants of the solar system that are beyond current technology.

This difficulty can be overcome by using a segment of the unpowered trajectory (Fig. 1) to establish what correction must be imparted to the vehicle in order that it arrive at the desired destination. To determine this correction, deviations in position between the ideal trajectory and the actual trajectory are measured as a function of the time of flight.

The Correction Impulse

The question that will be studied is how the propulsion system interacts with the guidance system in metering out this correction impulse. Although the trade-off considerations which are examined are greatly simplified, the principles which are involved can be readily altered to apply to more sophisticated situations. The model chosen for consideration in this problem is shown in Fig. 2. The vehicle at A is moving with a measured velocity V_0, with respect to the desired destination at D, and is at a distance P_x from it at $t = 0$. At time t_f, the vehicle will nominally arrive at its destination. It is further assumed that the mass variation during the flight is relatively small, as the correction will be small relative to the total velocity of the vehicle.

In the system which we have under consideration, the duration of the correction impulse will have a ma-

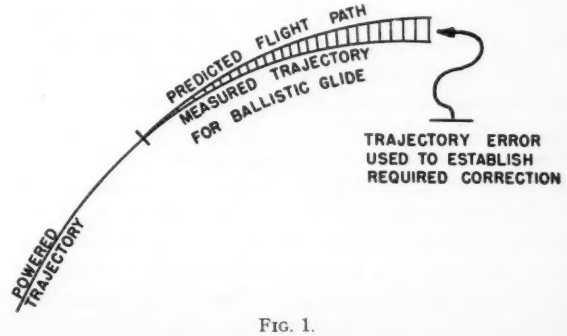

FIG. 1.

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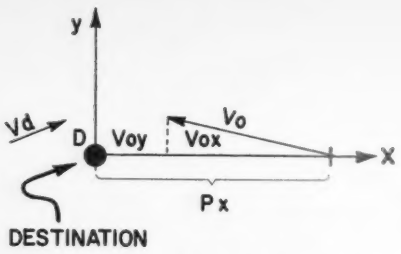


$t_f = Vox / Px$

FIG. 2.

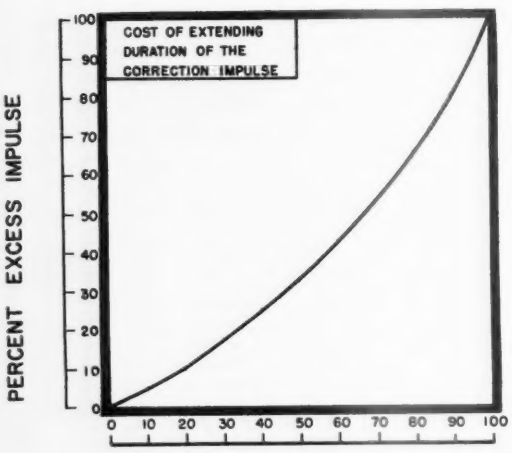


FIG. 3.

terial effect on both the guidance accuracy and the total fuel consumption. Fig. 3 shows the dependency of fuel consumption on the duration of the impulse. Note how extending the impulse duration doubles the fuel requirement for making the correction.

In all likelihood, the measurement of the acceleration vector will play an important part in the determination of the thrust cut-off time. The direct measurement of velocity which is the critical parameter in space guidance appears to be difficult if not impossible because of the great ranges to objects which might serve as reference reflectors for Doppler measurements. On the other hand, data derived from position time measurements along the accelerated trajectory will not yield adequate accuracy without paying an excessive price in added fuel consumption. In the light of this, it becomes important to understand the effects that the propulsion pattern will have upon the accuracy of the flight correction which is being introduced. The acceleration pattern of the propulsion system will interact with the acceleration sensitive guidance measurements in two ways: the first involving a rotation of the reference coordinates with respect to their initial alignment in space; the second involving direct nonlinearities in the acceleration sensitivity of the instrument itself.

The exact nature and magnitude of these will vary greatly depending upon the specific hardware used to implement the measurements. However, these errors can be formulated in terms of a series expansion of the accelerations undergone by the missile. Specifically, the angular misorientation α_m of the reference coordinate system can be represented as:

$$\alpha_m = \alpha_0 + (\Sigma \beta_i a_T{}^i)t \tag{1}$$

and the measured acceleration a_m represented a:

$$a_m = a_T + \Sigma \lambda_i a_T{}^i \tag{2}$$

where the β_i represents the drift coefficients for the angular reference systems and the λ_i represents the sensitivity of the accelerometer to various orders of nonlinearity.

In practice, only the lower order terms introduce any significant errors in the system performance to justify study. The impact of these errors can readily be calculated by integrating the equation over the complete trajectory of the missile. In the case of the coordinate reference system, the ϵ_x track and cross track ϵ_y errors can be computed as follows:

$$\epsilon_x = \int_0^{t_f} \int_0^t a_x(t)dt^2 \tag{3}$$

$$\epsilon_y = V_{0y}t_f - \int_0^{t_f} \int_0^t a_y(t)dt^2 \tag{4}$$

where

$$a_x(t) = \begin{cases} a_{y0} \sin \alpha_m(t) & t \leqq t_p \\ 0 & t > t_p \end{cases}$$

$$a_y(t) = \begin{cases} a_{y0} \cos \alpha_m(t) & t \leq t_p \\ 0 & t_p < t \end{cases}$$

so that

$$\epsilon_x / V_0 t_f = \beta_0 + (V_{0y}/2)\{\beta_1 + \beta_2 a_{y0}\}\{1 + 0.04(a_{min}/a_{y0})\} \tag{5}$$

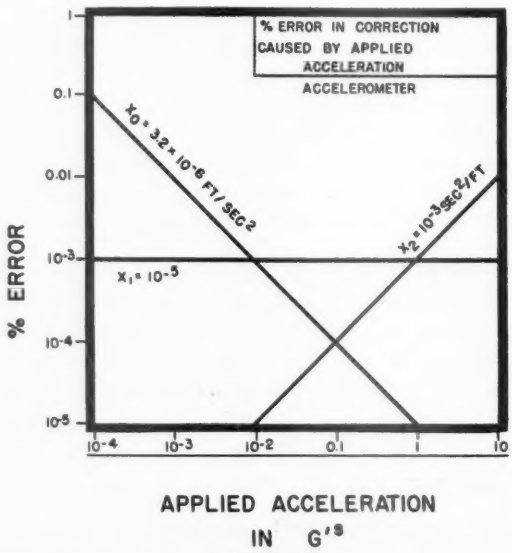


FIG. 4.

$$\epsilon_y / V_0 t_f = -(\beta_0^2/2) + (5/12)\{\beta_0\beta_1 + \beta_0\beta_2 a_{y0}\} V_{0y} + (1/2)\{\beta_1 + \beta_2 a_{y0}\}^2 V_{0y}^2 \quad (6)$$

The β_i is the same in nature as the drift coefficient of a gyroscopically stabilized platform: the zeroth order represents alignment error; first order—simple gravity dependent drift; second order—isoelastic drift. Fig. 4 summarizes the dependence of these errors upon the acceleration. At low levels of acceleration where alignment errors are the prime consideration, the error coefficient will be substantially independent of either total impulse or the applied acceleration. The first-order errors arising from a drift rate depend upon the total impulse only, not the manner in which it is applied; only for isoelastic and other higher order terms does the acceleration pattern become important.

Likewise, the errors resulting from the interaction between the acceleration profile of the propulsion system and the nonlinearity of the accelerometer can be computed by integrating the measured acceleration over the flight path of the vehicle

$$\epsilon_y = V_{0y} t_f - \int_0^{t_f} \int_0^t a_m(t) dt^2 \quad (7)$$

$$a_m(t) = \begin{cases} a_m & t \leq t_p \\ 0 & t \geq t_p \end{cases}$$

substituting Eq. (2) for a_m

$$\epsilon_y / V_{0y} t = (\lambda_0 / a_T) + \lambda_1 + \lambda_2 a_T \quad (8)$$

The λ_i are familar nonlinearity terms in accelerometers: the λ_0 representing an accelerometer bias; the λ_1 representing a scaling error in the accelerometer. It is significant to note that the choice of propulsion profile can do much to improve the performance of the acceleration measurement and, therefore, the guidance. Fig. 5 shows the dependence of the system errors on the applied acceleration.

The most common forms of terrestrial guidance today are based upon the continuous monitoring of position by direct contact. In space, the greater distance from reference objects vitiates its advantages. However, the higher possible resolution and the lesser absolute requirements for position information maintain it as a feasible method for space flight problems. Precision measurements will readily yield accuracies of 10^3 miles, and perhaps in the near interplanetary region this can be bettered by a factor of 5. If position measurements are to be used to establish the termination of thrust for the powered portion of a ballistic trajectory, serious problems arise. As seen from Fig. 6, unless a major portion of the flight is powered, the measurement errors must be multiplied by a large factor. This long duration of powered flight, on the other hand, results in a substantial increase in the amount of fuel consumed, as can be seen from Fig. 3.

The Problem of Errors

This large error multiplication results from the combination of the critical dependence of ballistic trajectories upon velocity information and the low grade of velocity information which can be derived from a sequence of position measurements.

The terminal position of the vehicle is given by the expression:

$$y(t_f) = y(t_p) + (t_f - t_p) V_{0y} + (t_p - t_f) \int_0^{t_p} a_T dt \quad (9)$$

The first two terms of $y(t_f)$ are direct measurements and contribute relatively little error to the miss distance. The last term presents a problem. It repre-

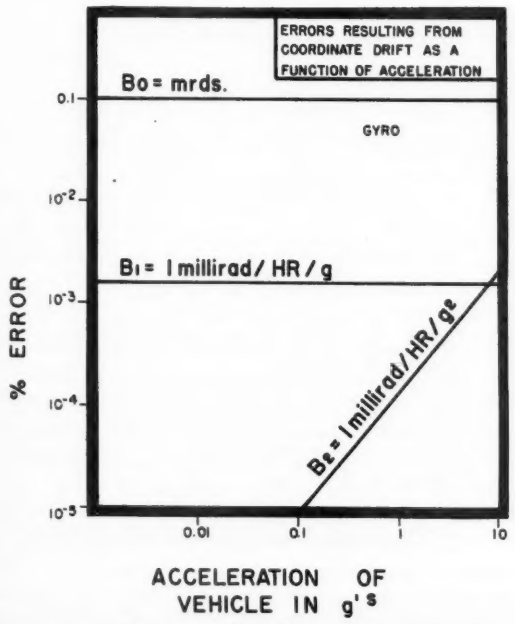
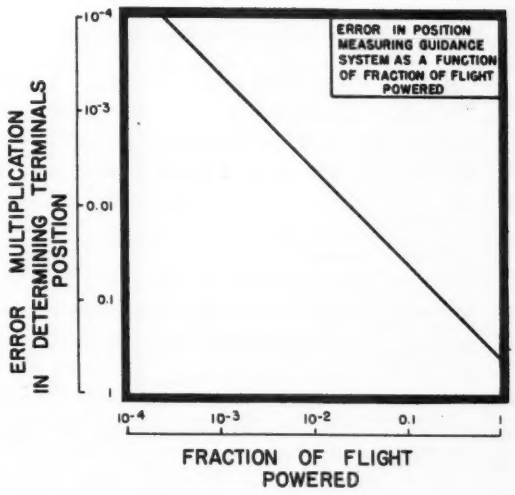


FIG. 5.



$$\text{Error} = \left\{ \frac{t_f}{t_p} - 1 \right\} 2S$$

FIG. 6.

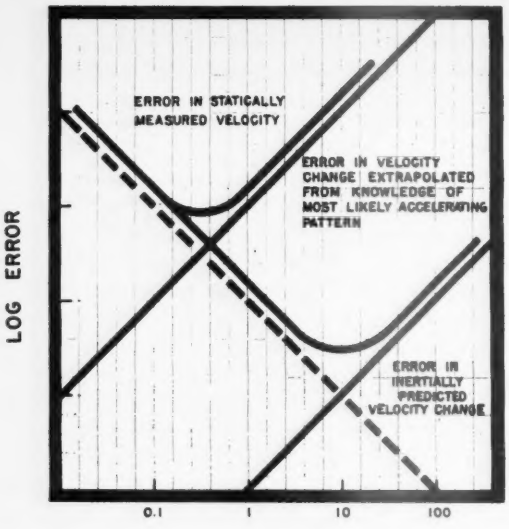


FIG. 7.

sents the velocity imparted to the vehicle during the thrust phase which is in progress. Its value must be determined from position measurements which are themselves inaccurate. To reduce the significance of errors in the position measurements, they should be displaced as far as possible in time. This, however, leads to the second problem that the vehicle is continuing to accelerate during the determination of the velocity. To minimize this second error, the position measurements should be made as close together as possible. Thus, the smoothing time must be so chosen as to balance the dynamic uncertainty built up during the measurement interval against the long smoothing time to minimize the uncertainties in the position measurements, as is shown in Fig. 7. At the expense of sensing the acceleration during the thrust phase, much better estimates of dynamic uncertainty may be made, as is shown in curve *b* of Fig. 7. This, in turn, allows a substantial reduction in the duration of the powered phase and a consequent saving of overall fuel weight.

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Research and Development Management in the Aero/Space Age

The Air Force believes that air and space form a single continuous operational field called aero/space.

Major Gen. M. C. Demler, USAF

General Demler, who has served in positions of increasing responsibility in the Air Force research and development organization for the last 20 years, is Director of Research and Development, Office of the Deputy Chief of Staff—Development, USAF. Holder of the Legion of Merit and Bronze Star Medal, he is a frequent participant in IAS activities, as well as one of its Fellows. He also is one of *Aero/Space Engineering*'s Editorial Advisers, serving on the Space Technology Panel.

BASIC IN THE philosophy in the research and development management of the Air Force is the premise that air and space form a single continuous operational field called aero/space. We accept the need for our military superiority at any level above the earth's surface if this nation and the free world are to survive.

But in the Aero/Space Age, military forces alone are not enough. We must also maintain predominance in all aspects of research and in our industrial know-how in order to ensure our future security. Out of our research and development effort we must continue to provide the complementary offensive and defensive forces which form our deterrent posture.

In today's race for survival it is not sufficient only to have the best capability; we must also be the first to have the best. An essential element in providing superior forces in time is a well managed and fully supported research program.

There may have been a period in the past when we could afford to obtain new knowledge or develop new techniques concurrently with a weapon system development program. Today, the delays encountered and the cost involved prohibit such a practice. Unless the knowledge and techniques required to develop any given system are available and feasibility is demonstrated. . . time will pass it by.

Systems designers today are rapidly absorbing the vast pool of knowledge and techniques which have been created over the years. The insatiable demand for new and more advanced methods is even more evidence that a strong research and development program is one of the best means of ensuring *timely* development of weapon systems. Those of you who are familiar with the Air Force research and development program structure know that we have divided the program into distinct elements. . .the Development Program and the Research Program. In the former, we manage the development of weapon systems, support systems, and equipment to meet stated operational needs for a specific time period. In the research program, we conduct the basic and applied research projects directed toward a qualitatively superior Air Force tomorrow by achieving technological superiority today.

Planning and Programing

The key to direction and continuity of our program is an effective planning and programing procedure. National objectives provide the starting point for scientific and technical planners at Headquarters USAF when they publish our research and development objectives each year. This guidance allows the Air Research and Development Command to prepare a Technical Plan to meet specific objectives of future Air Force weapon capability.

Using the Technical Plan as a basis, Research Planning Objectives and Technical Program Planning Documents are published for each of the areas in the research program. Technical Program Planning Documents specify what technical requirements must be solved in order to produce the techniques for the Air Force of the future.

Planning starts at the top level, but the programing cycle begins with the engineers and scientists in the ARDC Laboratories who can best appraise the state-of-the-art and the work that is needed to meet technical requirements. Each of the nine ARDC Centers prepares individual programs and forwards them to Headquarters ARDC where the segments are put into a total program. Because requirements normally exceed fund

Aero/Space Engineering is indebted to General Demler for this condensation of his address on "Air Force Research and Development Management in the Aero/Space Age" presented before the IAS New York Section in Little Falls, N.J., April 9, 1959.

availability, a system of priorities has been developed. All applied research objective priorities are based on future operational need, military advantage to be gained, technical deficiencies, cost, and risks involved. It is at this point that the program formulation relies heavily on the judgment, experience, and knowledge of research and development managers. Once prepared and consolidated, the program is forwarded to Headquarters USAF for review, approval, and budget preparation.

The total process of planning and programing is a lengthy one, but it is an orderly method which ensures that priority work is accomplished in a timely fashion.

A typical example of applied research which the Air Force has been sponsoring is the large liquid rocket engine. The million-pound rocket was conceived by the Air Force in 1955, and preliminary design of the engine was completed in December, 1955. Less than a year ago the ARPA requested the Air Force to let a contract for the initial phases of development. Progress on the program which is now under the NASA has been rather spectacular—a successful firing of a single thrust chamber, producing more than one-million-pound thrust, was accomplished in early March of this year. We feel that this is a significant step forward on the part of both industry and the Government.

Documentation and Dissemination of Technical Information

While planning and programing procedures are essential, we must also have adequate documentation and dissemination of technical information and technical requirements. In many instances, the methods for documenting, publishing, and distributing technical information have not kept pace with the increase in scientific knowledge. Inadequate announcement of technical progress can lead only to delays in development of operational systems. Inadequate publication of technical requirements invariably leads to duplication of effort by the scientific community.

We rely almost completely on the talents of industry, colleges, universities, and industrial research organizations to aid us in meeting tomorrow's needs. Dissemination of our technical requirements ensures the flow of new ideas and talents essential to the solution of our problems. Last year over 20,000 copies of the Technical Program Planning Documents were distributed to over 700 organizations.

Our current documentation procedures in the Air Force are adequate but far from ideal. We are devoting considerable time and effort to the mechanization of our reporting system. Our objective is a system of informing all centers and Headquarters ARDC less than 24 hours after the action is reported.

Conclusion

In conclusion, two significant trends in research and development programs of the Air Force are evident. The first of these will be an increased emphasis on basic and applied research. The second trend is increased emphasis on management techniques and organizations to support the scientific effort. Efficient management of research and development may be the deciding factor in the race for supremacy in the Aero/Space Age. Modern methods of management of research and development may be no less significant and complex than the technical work of research itself.

Management methods and organization are not in themselves an end objective. But wise and efficient management can harness an exploding technology and direct it to ensure our survival, as well as advance human welfare, in the world of tomorrow.

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Combining the known properties of boron and its oxides with experimental work done thus far in light of presently accepted oxidation and combustion theories, a reasonable choice of rate-limiting steps can be made for the oxidation of elemental boron in pure oxygen over a wide range of temperature and pressure.

Combustion of Elemental Boron

Claude P. Talley

Experiment Incorporated

Claude P. Talley is senior scientist and project leader in the Combustion Laboratory of Experiment Incorporated, Richmond, Va. Mr. Talley received his B.S. degree in Chemistry from the University of Virginia in 1952 and for the following three years worked on various industrial research projects in the Textile Fibers Department of the DuPont Company. In 1955, he joined the research staff at Experiment Incorporated where he has been mainly engaged in fundamental research related to combustion processes. Other work has included the preparation of elemental boron and the measurement of some of its properties.

THE THRUST of air-breathing jet engines is dependent on the addition of heat to a working fluid and, consequently, on the heating value of the fuel used. Fuels with high heats of combustion are, therefore, desirable. Because the fuel supply must be carried along in flight, it is quite important that it have a high heat of combustion per unit weight in order that the fuel supply not be excessively heavy and that it have a high density in order that it not take up too much space. It is seen in Table 1 that boron is superior in both respects to the other candidate solid fuels, carbon, magnesium, and aluminum. Gasoline is also included in the table for comparison. Thermodynamically then, boron would appear to be a very good solid fuel for these engines. However, whenever people have tried to burn boron, it would not burn efficiently.

The unclassified work at Experiment Incorporated which has been done on boron has dealt with this problem, and it is this work that is discussed here. We decided to carry out a fundamental laboratory study using materials of high purity with the objective of finding the rate-limiting step or steps in the burning of elemental boron and means for increasing these rates. In order to make the results more easily interpretable, most of the experiments thus far have been carried out in pure oxygen. Some work has been carried out in mixtures of oxygen and nitrogen corresponding to air, and it appears that many of the findings below in pure oxygen should be applicable to air. However, more experimentation will be required.

Experimental Methods

Because boron reacts with nearly everything at high temperatures, it was desirable to circumvent the container problem. This was done by preparing rods of boron which can be heated by electrical resistance heating up to the melting point of boron in various atmospheres. Boron rods (about 1 mm. in diameter) were prepared by the reduction of boron tribromide by hydrogen near a 25-micron-diameter tungsten wire electrically heated to temperatures between 1,200° and 1,700°K. boron brightness temperature. Conditions have been developed for making compact deposits of polycrystalline and glassy boron. Photomicrographs of these deposits are shown in Figs. 1 and 2. Wet chemical analysis for total boron indicated a boron content exceeding 99 per cent by weight. The main impurity in the boron rods was that of the 25-micron-diameter tungsten core which amounted to about 0.04 mole-per cent or about 0.7 per cent by weight. Emission spectrographic analysis indicated small amounts of

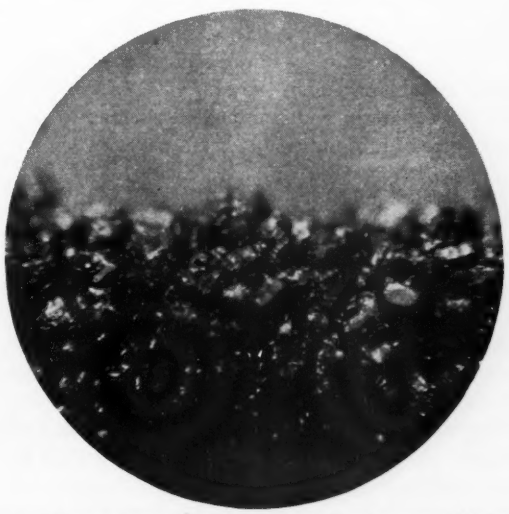

FIG. 1. Photomicrograph of a polycrystalline boron rod (approximately 1 mm. in diameter).

The support of the Office of Naval Research, Power Branch, for this work is gratefully acknowledged. The assistance of Quinton D. Overman, Jr., and Harold A. Rhodes with the experimental work and helpful discussions with Lloyd E. Line, Jr., all of Experiment Incorporated, are sincerely appreciated.

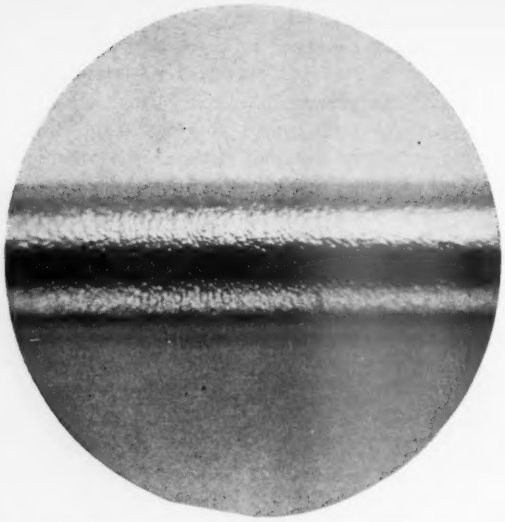

FIG. 2. Photomicrograph of a glassy boron rod (approximately 1 mm. in diameter).

Ca, Fe, Cu, Mg, and Si amounting to a total of 0.02 per cent by weight.

Relatively slow oxidation rates have been studied by electrically heating the rods to incandescent temperatures in a glass cell containing oxygen and measuring volumetrically the uptake of oxygen at constant pressure. Visible changes in surface character of the rods at temperatures up to 1,500°K. have been observed microscopically. Faster rates have been determined by burning the rods cigarette fashion in a stream of oxygen and measuring the linear rate of travel of the self-propagating reaction zone. In this case, the temperature in the reaction zone was maintained at around 2,300°K. solely by the heat of combustion of the boron.

Burning in Oxygen

While this study is still in progress, it has reached the point where it has yielded burning rate data in pure oxygen in the 1,100° to 2,300°K. range. By combining the known properties of boron and its oxides with the experimental work done thus far in light of presently accepted oxidation and combustion theories, a reasonable choice of rate-limiting steps in pure oxygen can be made.

Rate-Limiting Steps

Several distinct rate-limiting steps have been indicated, and the one that predominates depends greatly on the temperature and, to some extent, on the pressure. In these heterogeneous reactions, a number of processes occurs, any one of which may be rate-limiting. Some of the more obvious processes are:

Transport of oxygen—(a) diffusion in gas phase toward surface; and (b) diffusion through oxide surface layer toward boron in low oxidation state.

Chemistry—(a) reaction of oxygen with boron or a lower oxide of boron.

Transport of boron oxide—(a) liquid flow due to gravity; (b) evaporation from surface; and (c) diffusion in gas phase away from surface.

Transport of boron—(a) evaporation from surface as boron gas.

While it is, of course, imperative for oxygen to reach boron (or its lower oxide) in order for reaction to proceed, the most important steps over a wide temperature range involve the transport of boron oxide away from the reaction zone. The shift from one mechanism to another stems from the fact that boron oxide exists as solid, liquid, and gas over the temperature range of interest. For this reason, the oxidation of boron is unique among the solid fuels of Table 1 between room temperature and 3,000°K. For example, carbon would yield only gaseous carbon monoxide and carbon dioxide, magnesium would yield only solid magnesium oxide, and aluminum would yield only solid or liquid aluminum oxide.

In discussing the various rate-limiting steps, it is convenient to refer to the diagram in Fig. 3 which shows in a semiquantitative manner on temperature-pressure coordinates the areas where a particular process or processes are presently thought to be rate-limiting.

Region 1

Although no quantitative oxidation rate data have been obtained in this region, qualitative observations are that the reaction is extremely slow and that any oxide film formed would be solid. The rate-limiting step is probably reaction at the boron surface or transport of oxygen through the solid film which would result in the usual parabolic or logarithmic low-temperature rate laws[1] and a strong temperature dependence. Pressure would probably have little effect in altering the rate-limiting step, whereas raising the temperature above 723°K. would cause the oxide to melt, thus enhancing a shift to Region 2.

Region 2

This region begins at temperatures above the melting point of B_2O_3 (723°K.) where the liquid is free to flow away from the reaction zone under the influence of gravity in cases where the geometry of the reacting solid does not constrain the flow. Initially, as oxidation proceeds, a liquid oxide film builds up until it reaches a limiting thickness where viscosity, thickness, and surface tension of the liquid and the force of gravity combine to give a flow rate away from the reaction zone equal to the rate of production of liquid oxide. Since the film thickness is constant with time, the rate of transport of reactants to the reaction zone is also con-

TABLE 1
Thermodynamic Comparison of Fuels

Fuel	Density, gm./cc.	Heat of Combustion— Kcal./gm.	—Heat of Combustion Kcal./cc.
Boron	2.34	13.9	32.4
Carbon	2.25	7.83	17.6
Magnesium	1.74	5.91	10.3
Aluminum	2.70	7.42	20.0
Gasoline	0.74	11.5	8.51

stant. This results in a reaction rate which is constant with time corresponding to the linear rate law. During the initial build-up of coating, the reaction rate would approximate the parabolic rate law. In the lower part of Region 2, a longer time would be required for establishment of steady state than in the upper portion where the reaction rate would be faster.

As the temperature is increased to approximately 1,100°K., the rate of evaporation of oxide becomes appreciable and finally comparable to the rate of removal of oxide by flow of liquid under the influence of gravity. Since the oxide is now being removed by two mechanisms, the steady-state film thickness decreases, provided the external conditions (to be discussed more fully in the next section) are such that evaporation continues when steady state is reached. Because the film thickness decreases, the tendency for removal of oxide by flow of liquid decreases until, finally, the film thickness is determined solely by the evaporation rate of the oxide, which is the rate-limiting step in Region 3.

Region 3

As previously mentioned, the oxidation rate is limited in this region by the evaporation of products from the surface of the liquid film. More precisely, the rate-limiting step is the net evaporation rate or the rate of gas-phase diffusion of products from the surface of the liquid film. Region 3 can exist in steady state only when conditions are such that gas-phase diffusion of products continues when steady state is reached and is fast compared to the liquid flow rate in cases where flow of liquid is not constrained. (In cases where the liquid is constrained and conditions are such that gas-phase diffusion of products cannot continue in steady state, then it would be possible for Region 1 involving a liquid instead of solid oxide film to extend to Region 4.) Examples of such conditions which meet the first requirement are when boron is burned in a stream of oxygen or in oxygen that has a lower bulk temperature than the boron. Partly because it was less difficult to do experimentally and partly because these conditions approximate actual combustion, most of the experimental work has been carried out under these conditions. The second requirement tends to be satisfied as the temperature of the boron is increased. The division between Regions 2 and 3 has been drawn in semiquantitatively in Fig. 3 for the case of an electrically heated 1-mm.-diameter boron rod burning in oxygen contained in a small Pyrex glass tube with relatively cold walls.

For steady-state oxidation in Region 3, the rate of removal of the oxide is the key process rather than the rate of transport of reactants. In other words, the rate of transport of reactants merely keeps pace with the rate of transport of oxide instead of setting the rate of reaction. This is evident because if the rate of evaporation of oxide is caused to increase, the oxide film thickness decreases until the rate of transport of reactants to the reaction zone increases (because of the reduced path length) to a value equivalent to the rate of evaporation of oxide. If the rate of evaporation of oxide is caused to decrease, then the converse would be true.

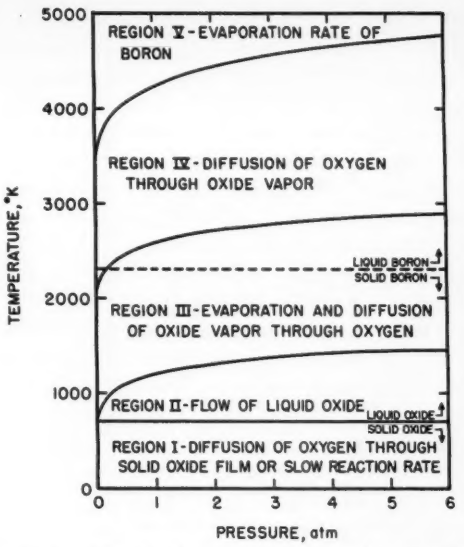
5000
4000
3000
2000
1000
0
TEMPERATURE, °K
REGION V - EVAPORATION RATE OF BORON
REGION IV - DIFFUSION OF OXYGEN THROUGH OXIDE VAPOR
LIQUID BORON
SOLID BORON
REGION III - EVAPORATION AND DIFFUSION OF OXIDE VAPOR THROUGH OXYGEN
REGION II - FLOW OF LIQUID OXIDE
LIQUID OXIDE
SOLID OXIDE
REGION I - DIFFUSION OF OXYGEN THROUGH SOLID OXIDE FILM OR SLOW REACTION RATE
0 1 2 3 4 5 6
PRESSURE, atm

FIG. 3. Semiquantitative map showing various rate-limiting processes in the oxidation of elemental boron in oxygen as a function of temperature and pressure.

Thus, the film thickness reaches a limiting value where in steady state the rate of transport of reactants to the reaction zone is equal to the rate of gas-phase diffusion of products from the surface. This results in a constant oxidation rate with time which corresponds to the linear rate law. In gas-phase diffusion the rate is proportional to the pressure gradient. The proportionality "constant" is inversely proportional to total pressure and directly proportional to the square root of temperature. The pressure gradient in Region 3, for the most part, is approximately proportional to the vapor pressure of the evaporating liquid, which, in turn, is an exponential function of temperature. Therefore, in general, the diffusion rate (and, therefore, the oxidation rate) in Region 3 will be inversely proportional to the total pressure and exponentially related to the temperature of the oxide film (the exponential takes precedence over the square root of temperature introduced by the proportionality "constant"). This situation leads to the interesting result that the reaction rate is limited by gas-phase diffusion and yet is an exponential function of temperature. At low pressures, the diffusion rate is rapid and approaches as a limit the evaporation rate into a vacuum. Therefore, one would expect the transition from Region 2 to Region 3 to take place at lower temperatures for low pressures than for high pressures.

Region 4

As the temperature is raised higher and higher in Region 3, the steady-state film thickness of boron oxide becomes smaller and smaller until the film finally vanishes, leaving the solid boron surface exposed to the gas phase. This situation causes a transition from Region 3 to Region 4 where the rate is no longer retarded by the presence of a protective liquid coating but,

rather, is limited by the gas-phase diffusion of oxygen through boron oxide vapor.

It appears that chemical reactivity would be a controlling factor only at relatively low temperatures and pressures. The boron surface is likely to become free of liquid oxide at temperatures near that required for the vapor pressure to be comparable to the total pressure of the system. Therefore, the vapor pressure curve of the evaporating oxide should approximate the division between Regions 3 and 4. The vapor pressure curve for B_2O_3 was used for this purpose in Fig. 3.

As in Region 3, gas-phase diffusion is the rate-limiting step, and a linear rate law is followed, but in Region 4 a different diffusing material is controlling the reaction rate—namely, gaseous oxygen. The pressure gradient of oxygen would not be subject to the exponential temperature dependence, as in the case of the boron oxide in Region 3. Therefore, it would not be surprising if the reaction rate is a relatively weak function of temperature, a characteristic of most gas-phase diffusion processes. Also, the reaction rate is likely to be independent of pressure because the diffusion coefficient is inversely proportional to pressure and the pressure gradient is nearly proportional to pressure.

Region 5

At any given pressure, as the temperature is raised in Region 4, the evaporation and subsequent gas-phase oxidation of elemental boron becomes increasingly important. When the vapor pressure of the boron is greater than the total pressure, the evaporation rate of boron would be rate-limiting because it would be faster than the diffusion of oxygen to the boron surface.

The transition would take place at lower temperatures for low pressures than for high pressures, and the division between Regions 4 and 5 is approximated in Fig. 3 by the vapor pressure curve of elemental boron. At temperatures above about 2,300°K., liquid boron would be present. However, the transition from solid to liquid boron would not be expected to change the rate-limiting step. Since the rate-limiting step is the evaporation rate of boron, the rate of combustion would follow a linear rate law and be expected to vary exponentially with temperature with an activation energy comparable to the heat of vaporization of boron (about 130 kcal./mole). The total pressure would not be expected to affect the rate of consumption of boron greatly.

Evidence for Various Mechanisms

A considerable amount of work has been done to show the existence of Region 3. At this time little is known experimentally about Regions 1, 2, 4, and 5. However, by combining the known properties of boron and its oxides with the experimental work done here thus far, in light of presently accepted oxidation and combustion theories, the rate-limiting steps appear reasonable. The case for Region 1 has already been discussed. In regard to Region 2, we have observed the build-up of a transparent viscous liquid coating on cylindrical boron rods at 1,200°K. in oxygen at one atmosphere and the subsequent flow of the coating to the lower portions of the rod, which, apparently, maintains a constant film thickness over the major portion. Under these conditions, the reaction rate was constant for 30 min. after the initial build-up of the film. A reaction rate approximating the parabolic rate law has been observed during initial build-up of film under similar conditions.

There is ample evidence for the existence of Region 3. A transparent viscous liquid coating has been observed to cover the boron surface completely as a uniform thin film (about 10μ thick at about 1,400°K.). An oxide product whose analysis showed 85 to 89 per cent B_2O_3 condensed on the relatively cold walls of the cell in which the boron was oxidized. After an initial build-up of oxide on the boron, the uptake of oxygen was found to be linear for periods up to 150 min. The rate was found to be inversely proportional to pressure. No difference was found in the oxidation rate of polycrystalline and glassy boron. A large temperature dependence corresponding to about 60 kcal./mole was obtained for the oxidation rate between 1,250° and 1,500°K. which is comparable to the heat of vaporization of B_2O_3, which is about 79 kcal./mole at 1,400°K. The experimental oxidation rate was found to be of the same order as the calculated evaporation rate of oxygen as B_2O_3 from the surface of the rod in a vacuum. Although it seems likely in an oxidizing atmosphere that B_2O_3 is the species that evaporates from the surface, it is possible that some other species, such as B_2O_2, evaporates from the surface and then reacts in the gas phase to form B_2O_3. The heat of vaporization and the calculated evaporation rate of B_2O_2 compares with the experimentally determined temperature dependence and oxidation rate about as well as the values for B_2O_3. However, it is not necessary to determine what the species is in order to prove the existence of Region 3.

The existence of Region 4 is thought to be reasonable because little or no liquid film has been observed on boron surfaces after burning at about 2,300°K. in oxygen at one atmosphere. The film thickness at 2,300°K. calculated from the temperature dependence of the oxidation rate and film thickness at 1,400°K. in Region 3 is about 10^{-8} cm. This crude calculation thus suggests that around 2,300°K. in oxygen at one atmosphere the liquid film should vanish. This agrees roughly with the division between Regions 3 and 4, represented by the vapor pressure curve of B_2O_3 in Fig. 3.

Region 5 is based on nothing more involved than the consequences of the sublimation or boiling of any material. When the vapor pressure of a material is greater than that of the surrounding gases, they will be forced back from the surface, and the amount of the condensed material will decrease at a rate equal to the sublimation or evaporation rate characteristic of the material.

Some Consequences of the Mechanisms

We have observed qualitatively that powdered boron is more difficult to burn in self-propagating fashion than

(*Continued on page 47*)

"Given any specific mortality function. . ., whether in the form of an analytic expression, a graph, or a table of corresponding values, the corresponding probability density function may be determined. This is the function that should be used in predeterminations of the reliability of the device concerned."

Specific Mortality of Engineering Devices

L. V. Toralballa
New York University

L. V. Toralballa holds a B.S. degree in mechanical engineering from the University of the Philippines and a Ph.D. in mathematics from the University of Michigan. He is an associate professor of mathematics at New York University. In connection with aerial surveying, Dr. Toralballa has extended the basic photogrammetric equation to the case when the wind is nongeostrophic. He also has done some studies in connection with the predetermination of the reliability of rockets and missiles.

THERE IS a class of modern engineering devices which are, quite frequently, rather short-lived. In this class are included certain electronic missile guidance systems, as well as certain components of rockets. An important problem in connection with such devices is the predetermination of the reliability of a given stock. This is, to a great extent, a statistical problem. As such, its solution requires the use of a probability density function of the lengths of life of the devices under consideration. A number of such density functions have been in use—notably, the Poisson distribution function.

$$f(x) = (1/\theta)e^{-(x/\theta)}$$

The point, however, does not seem to be generally realized to a sufficient degree that different periods of the development of a device may well call for widely differing probability functions. The situation here is not unlike that which held in the social sciences a few decades ago when the normal, or Gaussian, distribution function was thought to be adequate in representing variability in all manner of phenomena.

The aim of this paper is to describe the relation between a given probability density function and another function, the corresponding specific mortality function, and to indicate how the latter can provide an initial criterion for the adequacy of the former in representing variability in a given phenomenon.

The graph most directly obtainable from test to destruction data is that showing the number of units, out of a given number initially under test, which are still working properly at a given time t as a function of the time. A usual test scheme is to place, say, n_0 units under a destructive test and to record the time when each failure occurs. From these data, one obtains a graph of the general form shown in Fig. 1. The ordinate n corresponding to t gives the number of units still in function t hours after the start of the test. The curve is, of course, monotonic nonincreasing.

From the graph in Fig. 1 it is seen that the number of units that failed during the time interval from t to $t + \Delta t$ is $-\Delta n$. Hence, the number of units whose total life lies between t and $t + \Delta t$ is precisely $-\Delta n$. If we seek $f(t)$, a function which differentially expresses the probability that a unit taken at random from the starting stock has a total life lying between t and $t + dt$, then we proceed thus:

$$n_0 f(t)dt = -dn$$

$$f(t) = -(1/n_0)(dn/dt)$$

We observe that dn/dt, as a function of t, is merely the first derived curve of $n = F(t)$. $f(t)$ is the probability density function corresponding to the function $n = F(t)$.

A third, related, function, which—as the sequel shows—is rather instructive, is

$$g(t) = -(1/n)(dn/dt)$$

At any given time t, $g(t)$ expresses the ratio between the rate of mortality at the time t and the number of units in function at that instant of time. Thus $g(t)$ has the nature of what may be called specific mortality. We shall refer to $g(t)$ by that name.

Specific Mortality Function

$g(t)$ gives an indication of the severity of mortality, independent of the numbers subject to this mortality.

Fairly extensive data obtained from tests instituted by industry on the life of a class of devices at a somewhat early period of development gave a specific mortality function of the general form shown in Fig. 2.

It is noticed that between $t = a$ and $t = b$, $g(t)$ is nearly constant. At $t = 0$, the ordinate is high, indi-

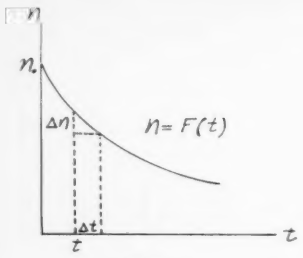

FIG. 1.

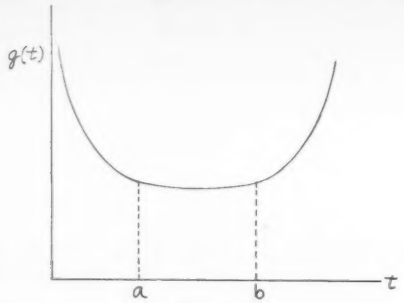

FIG. 2.

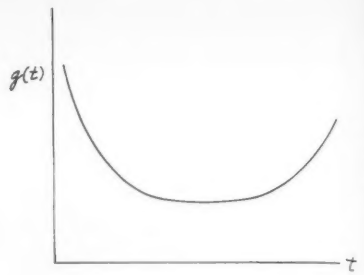

FIG. 3.

cating that a considerable percentage of the units are much below standard in quality. These units are very short-lived. The percentage of units going out of function decreases sharply as t goes from $t = 0$ to $t = a$, indicating that the units that survive are increasingly superior intrinsically. From $t = a$ to $t = b$, the specific mortality is almost constant. This indicates that, in this interval, the surviving units are about equal in overall quality. In this interval, mortality is nearly a stochastic or random matter. After $t = b$, the specific mortality increases somewhat sharply. This seems to indicate that, after this point, mortality is due to an accumulation of fatigue. This region should perhaps be considered an "off design" region.

Where the device under consideration is at a high state of development and the units are manufactured under very close quality control, one would expect that the length of the interval from $t = 0$ to $t = a$ would be small in comparison with the length of the interval from $t = a$ to $t = b$.

We shall now return to the analytical relation between the probability density function $f(t)$ and the specific mortality function $g(t)$.

$$f(t) = -(1/n_0)(dn/dt) = -(1/n_0)(dF/dt)$$

$$dF = -n_0 f(t)dt$$

$$F(t) = -n_0 \int_0^t f(t)dt + n_0$$

$$g(t) = -(1/n)(dn/dt) = (n_0/n)f(t)$$

$$= \frac{n_0 f(t)}{n_0\left[1 - \int_0^t f(t)dt\right]} = \frac{f(t)}{1 - \int_0^t f(t)dt}$$

This expresses the specific mortality in terms of the probability density function.

It is interesting to determine the specific mortality function corresponding to the Poisson distribution function.

$$f(t) = (1/\theta)e^{-(t/\theta)}$$

$$(1/\theta)\int_0^t e^{-(t/\theta)}dt = -e^{-(t/\theta)}\Big]_0^t = 1 - e^{-(t/\theta)}$$

Hence, $g(t) = 1/\theta$, a constant. It is thus apparent that the Poisson probability density function is appropriate only where the two side parts of the actual specific mortality curve are negligible compared with the central part. This seems to indicate that this distribution is appropriate only when the device is at a high degree of development and when the units are manufactured under very close quality control.

We now want to express the probability density function in terms of the specific mortality function.

$$g(t) = [f(t)]\Big/\left[1 - \int_0^t f(t)dt\right] \qquad \text{Let } k(t) = \int_0^t f(t)dt$$

$$g(t) = [k'(t)]/[1 - k(t)]; \quad g(t)[1 - k(t)] = [dk(t)]/dt$$

$$[dk(t)]/[1 - k(t)] = g(t)dt$$

$$\ln [1 - k(t)] = -\int_0^t g(t)dt$$

$$1 - k(t) = e^{-\int_0^t g(t)dt}; \qquad k(t) = 1 - e^{-\int_0^t g(t)dt}$$

$$\int_0^t f(t)dt = 1 - e^{-\int_0^t g(t)dt}$$

$$f(t) = g(t)e^{-\int_0^t g(t)dt}$$

This is the desired expression. When $g(t) = 1/\theta$, a constant,

$$f(t) = (1/\theta)e^{-\int_0^t (1/\theta)dt} = (1/\theta)e^{-(t/\theta)}$$

Thus, whenever the specific mortality is a constant, the corresponding probability density function is the Poisson function.

Probability Density Function

Given any specific mortality function $g(t)$, whether in the form of an analytic expression, a graph, or a table of corresponding values, the corresponding probability density function may be determined. This is the function that should be used in predeterminations of the reliability of the device concerned.

Suppose that the force of mortality function has a graph of the form shown in Fig. 3. It may be possible to represent the graph adequately by a generalized parabola, $g(t) = (c\,t - m)^{2n} + a$, where n is a positive integer, sufficiently large for approximating the nearly flat portion of the graph. Then the appropriate probability density function may be arrived at thus:

(*Continued on page 47*)

Experimental data on several candidate radome ceramics are reported for thermal stresses both perpendicular and parallel to the radome wall. Data are reported for Pyroceram Brand glass ceramic, high purity alumina, and fused silica. The test medium was a molten salt bath. The desirability of a low thermal expansivity in this application is demonstrated.

Thermal Shock Resistance

A Design Parameter for Ceramic Radome Walls

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Corning Glass Works

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Mr. Shand is a technical consultant to the glass industry. He received a bachelor's degree from McGill University in 1915 and shortly afterward joined the Westinghouse Electric Corporation. He joined Corning Glass Works in 1936 and was active in the development of fiber glass. Prior to his retirement from the company last year, Mr. Shand had served as staff research engineer for the Research and Development Division. He is author of the *Glass Engineering Handbook*.

PRESENT TRENDS toward higher missile speeds are making increased demands on radome materials. These demands include not only the maintenance of physical properties at high temperature but also the ability to withstand the thermal stresses developed by the transient temperature changes within the radome wall. Most physical properties of materials can now be measured at elevated temperatures using established procedures. No procedure which is both simple and effective has yet been developed for determining resistance to thermal shock conditions found in radomes.

Two general methods are available for the study of this characteristic—one is experimental, the other analytical. The experimental proving of the finished radome can be carried out in flight tests when mounted on a missile, in a wind tunnel, or by the rapid heating of the outer surface by one of several means. However, if radiant heat is used, the possible effect of radiation conductivity of the radome material should be checked.

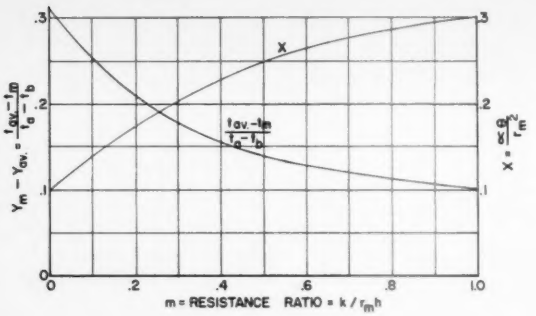
In the earlier design stages of missile development, analytical methods are ordinarily utilized. Stress computations are based on the estimated temperatures of the air film at various stations along the radome profile, which take into account the size and shape of the radome, and on the thermal and mechanical properties of the radome material. The relationship between the total stress components, including thermal stresses and those resulting from aerodynamic forces, and the breaking stress of the material indicate the suitability of the proposed design.

This analytical treatment has certain limitations. The computation of thermal stresses lacks a high degree of precision. Furthermore, the stress behavior of the radome material in flight environment may differ materially from that indicated by a somewhat arbitrary standard strength test. As a consequence, it is highly desirable to have some relatively simple method for measuring thermal endurance which correlates with flight conditions. This discussion describes preliminary work of an attempt to do this.

The subject was discussed by Mr. Luoma at the Ohio State University Air Development Center Radome Symposium, Columbus, Ohio, June, 1958. His presentation has been updated in this paper to include the most recent developments in this field.

Thermal Stresses in Radomes

During the acceleration of a missile, the temperature of the air film in contact with the radome surface will rise rapidly to a high value. These temperatures will be higher at the tip of the radome than at points further back on the ogive. Heat is transferred across this air film to the radome and raises the wall temperature. Temperature gradients will exist through the wall sections and also axially along the outer surfaces. If the mounting structure or ring extends over the outer surface of the radome, the axial gradient will be accentuated. The temperature gradient through the wall section develops stresses which are parallel to the radome wall; while the axial gradient develops stresses which are mainly circumferential.



PEAK VALUE OF $\frac{t_{av.}-t_m}{t_a-t_b}$ VERSUS RESISTANCE RATIO, m, AS TAKEN FROM HOTTEL CHARTS FOR SUDDEN HEATING OR COOLING OF SLAB

t_a = AMBIENT TEMP. — k = THERMAL CONDUCTIVITY
t_m = TEMP. AT MIDSECTION — α = THERMAL DIFFUSIVITY
t_{av} = AVERAGE TEMP. OF SLAB — r_m = HALF THICKNESS OF SLAB
t_b = ORIGINAL TEMP. OF SLAB — θ = TIME FROM AMBIENT CHANGE
h = HEAT TRANSFER COEFFICIENT OF FILM

FIG. 1

Under transient conditions of acceleration, the temperature gradient through the wall will be greater near the outer surface than near the inner surface. The temperature distribution through the wall section can be determined analytically by means of analog computers or by methods of finite differences as proposed by Dusinberre.[1, 2] This latter method has been programed for digital computer operations.

The thermal stress at any point across the radome section is proportional to the difference between the temperature at this point and the average temperature of the section, thus:

$$\sigma = [\alpha E(T_x - T_{\text{avg.}})]/(1 - \nu) \qquad (1)$$

where

α = coefficient of expansion with temperature
E = modulus of elasticity
ν = Poisson's ratio
T_x = temperature at the point
$T_{\text{avg.}}$ = average temperature of the section

When the temperature of outer surface is rising rapidly, the compressive stress at the outer surface will be much greater than the tensile stress at the inner surface. However, in the case of ceramics, this compressive stress will not induce failure and can be neglected. The tensile stress is a complex function of the time-temperature history of the outer surface, but will not be a direct function of the rate of temperature rise.

For purposes of illustration, the temperature relations in a radome under acceleration can be compared with those in a slab or plate with a thickness double that of the radome wall plunged into a medium at a temperature roughly equivalent to that of the maximum value of the air film. Under these conditions, a fictitious heat-transfer coefficient of the film must be assumed which will permit the surface temperature to rise at approximately the same rate as that of the actual radome.

Certain interesting relationships for these conditions can be derived from the Hottel charts (McAdams,[3] Chap. 3) which are shown in terms of several dimensionless quantities. Fig. 1 is an additional chart derived from these Hottel charts. It shows the maximum value of $(t_{\text{avg.}} - t_m)/(t_a - t_b)$ as a function of m—in other words, the relationship between the temperature difference which gives maximum tensile stress at the inner surface $(t_{\text{avg.}} - t_m)$ as a function of the value m which determines the rate of temperature rise of the outer surface. The smaller the value of m, the greater will be the rate of surface rise. (This rate of rise can be obtained indirectly from Fig. 3-4 of McAdams.) For the range of rates of rise included in Fig. 1 the tensile stresses at the inner surface are found to vary over a range of 1 to 3.

The maximum shear stress resulting from the temperature gradient parallel with the axis may be expressed by the equation

$$\sigma = (1/2)\Delta T \alpha E \qquad (2)$$

where

ΔT = the temperature difference involved
α = coefficient of expansion
E = modulus of elasticity

When the corresponding tensile stress is considered and when the temperature gradient is low, the actual stress which represents the criterion of failure will be considerably lower.

Experimental Procedure

The experimental work consisted in making up experimental specimens of simple shape and immersing them in a bath of molten salt held at various temperatures. The specimen was held stationary while the container of the fused salt was rotated in order to permit uniform heating of the salt bath.

The shapes and dimensions of the specimens used are

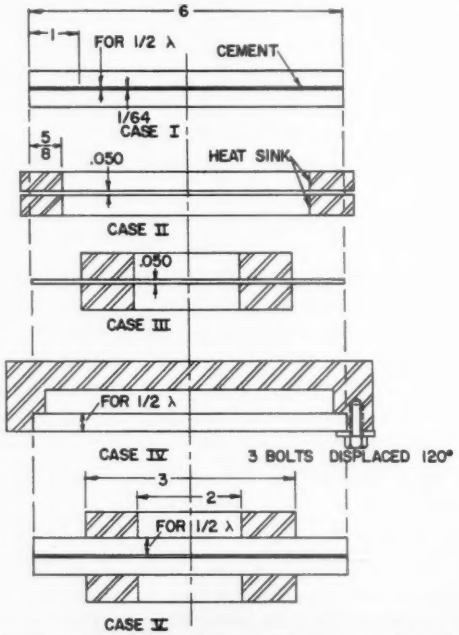


FIG. 2. Assembly for specimens used on thermal shock tests.

TABLE 1
Radome Materials and Their Properties

Material	Density, Sp.g.	Thermal Conductivity, B.t.u./(hr.)(ft.)(°F.)	Modulus of Elasticity, 10^6 psi	Dielectric Constant	Wall Thickness,* 1/2 (in.)
Alumina	3.8	12.5–14.0	40	8.5	0.228
Pyroceram (9606)	2.6	1.95	17.3	5.5	0.293
Pyroceram (9608)	2.5	1.13	12.5	6.5	0.265
Silica glass (7940)	2.2	0.67	10.5	3.8	0.369

* Wall thicknesses for specimen Cases I, IV, and V correspond to halfwave wall.

indicated in Fig. 2. Flat plates 6 in. in diameter were used in all instances. This simplifies fabrication of specimens.

Case I

For stresses produced by gradient through the wall: This specimen is composed of two plates, each of a thickness equivalent to one-half wavelength based on the dielectric constant of the specific material and for an assumed frequency. The two plates are cemented together at the edges to provide the proper constraint, while the inner surfaces provide the surface of a strength corresponding to the inner surface of the radome. The cavity between the two plate sections was vented in order to prevent the build-up of internal pressure.

Case II

For stresses produced by parallel gradient: The specimen is a plate 0.050 in. thick provided with a metal heat sink around the edges. The thinner section of these specimens is intended to reduce the thermal gradient perpendicular to the surface. These metal rings tend to hold the temperature of the plate, so protected, at its original value, while that of the exposed area in the center is raised suddenly from contact with the fused salt.

Case III

This is a modification of Case II. The heat sink in this case is removed from the edges of the plate. This design is to eliminate the possibility of breakage due to edge flaws. Test results from Case II and Case III show little difference, so that one type, probably Case II, can be omitted in further tests.

Case IV

This arrangement was intended to produce combined stresses of Case I and Case II. However, because the constraint found in Case I is not duplicated, the stresses resulting from the gradient through the plate are reduced greatly, as is apparent from the results listed in Table 2. This test will be eliminated in future work.

Case V

This is to produce the combined stresses of Case I and Case III. Results from this arrangement are believed to be significant; it will therefore be retained.

The materials tested are listed in Table 1, together with their properties.

The errors involved in attempting to measure surface temperature with thermocouples are now well appreciated. In order to overcome this difficulty, a special plate specimen with three holes drilled into the wall was used to obtain an evaluation of the heat-transfer coefficient at the surface of the plates. Thermocouple readings taken in these holes were extrapolated to give surface temperature values under transient conditions.

In the case of the thermal endurance tests, the temperature of the salt bath was raised in steps from test to test until failure of the ceramic material occurred.

Test Results

Data are given in Table 2 in terms of the bath temperatures; W = withstood and B = broke.

Surface Heat-Transfer Coefficient

The temperatures within the section of the plate after immersion in the fused salt are shown in Fig. 3. These values have been extrapolated to the inner and outer surface. Temperatures at the two surfaces and at one intermediate point are shown as a function of time in Fig. 4. The initial rate of temperature rise at the outer surface is estimated to be approximately 5°F./-sec. The value of h, or the heat-transfer coefficient at the outer surface, can be computed from the Dusinberre equation:

$$(T_2 - T_1) + N(T_0 - T_1) = (M/2)(T_1' - T_1) \quad (3)$$

where

T_0 = bath temperature
T_1 = surface temperature of the plate

TABLE 2
Breaking Temperature, B°C., vs. Withstanding Temperature, W°C.

Material	Case I	Case II	Case III	Case IV	Case V
Pyroceram 9606	*B 900 W 900	B 200 W 150	B 250 W 200	*B 975 W 975	B 600 W 550–650
Pyroceram 9606 fortified			B 650 W 600		
Pyroceram 9608	*B 925 W 925	B 650 W 600	B 800 W 750	*B 925 W 925	*B 925 W 925
Fused silica		B 550 W 450		*B 975 W 975	
Alumina	B 600 W 650	B 200 W 150	B 250 W 200	B 450 W 400	B 500–700 W 450–550

* Upper temperature limit of salt bath was between 900°C. and 1,000°C.

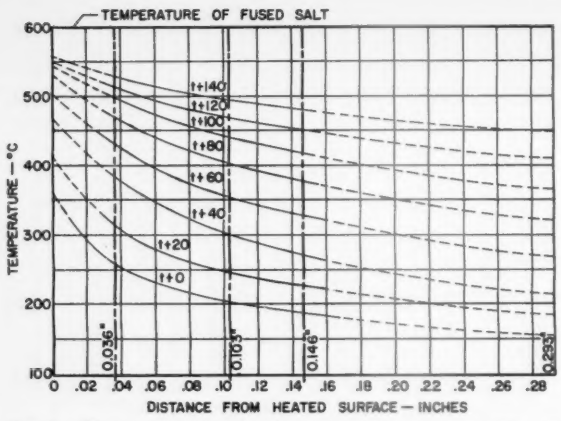


FIG. 3. Temperature distribution through specimen at different time periods.

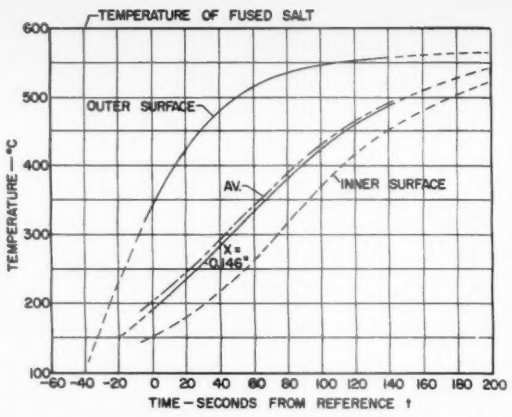


FIG. 4. Temperature variation with time at different points in wall section.

T_2 = temperature at a distance Δx from the surface

k = thermal conductivity of the material

$N = h\Delta x/k$

T_1' = surface temperature after time increment Δt

For the conditions considered, Eq. (3) reduces to the approximation

$$N = (T_2 - T_1)/(T_0 - T_1) \qquad (3a)$$

or

$$h = (k/\Delta x)(T_2 - T_1)/(T_0 - T_1) \qquad (4)$$

From the data of Fig. 4 it is found that h averages 0.055 cal./(sec.)(cm.^{2}) (°C.) or 0.115 B.t.u./(sec.)(ft.^{2})-(°F.).

Fig. 4 shows an initial rate of rise on the surface of approximately 6.7°C./sec. or 12°F./sec. From the Hottel chart, Fig. 1 indicates that, if this rate of rise were increased to 50°F./sec., the resulting tensile stress at the inner surface would be increased by 70 per cent. This can be taken as only a rough approximation.

Results of the thermal shock tests are given in Table 2. Considering the different types of specimens, it is noted that, except for Case IV, Case I is the least severe. For the parallel gradient tests, Case III is slightly less severe than Case II, although the difference is not great. Case II is the most severe of all these tests. This arrangement of the heat sink produces stresses relatively much greater than those which would occur in the actual radome because of the sharp gradient which occurs at the boundary of the metal rings. This is also true to a lesser degree for the arrangement of Case III. Because of the lack of constraint of the test plate in Case IV, stresses resulting from the perpendicular gradient will be reduced greatly so that the results of this type of test are not significant. For Case V, this breaking temperature for Pyroceram material 9606 is lower than for Case I. For alumina, this temperature appears to be slightly greater.

Considering now the various materials tested, it is apparent that Pyroceram material 9608 and silica glass 7940 will withstand more severe thermal shocks than the other materials tested. This is because of their low thermal expansion characteristics which greatly reduce the thermal stresses.

Pyroceram material 9606 shows greater resistance than alumina, in spite of the greater mechanical strength of the latter material. Use of a recently developed process to increase the surface strength of Pyroceram 9606 shows a 400°C. increase in breaking temperature in the single test series made under this condition. This result demonstrates the importance of chemical fortification of glass ceramic materials.

Relative thermal shock resistance of a material is determined by the relationship between its strength and the stress produced by temperature differences. An important factor influencing stress is the thermal stress modulus, $E\alpha/(1 - \nu)$, Eq. (1). Table 3 gives commonly listed values of the properties involved; however, the thermal stress modulus, as well as the breaking stress, is found to be a function of temperature as indicated in Fig. 5. This curve explains to

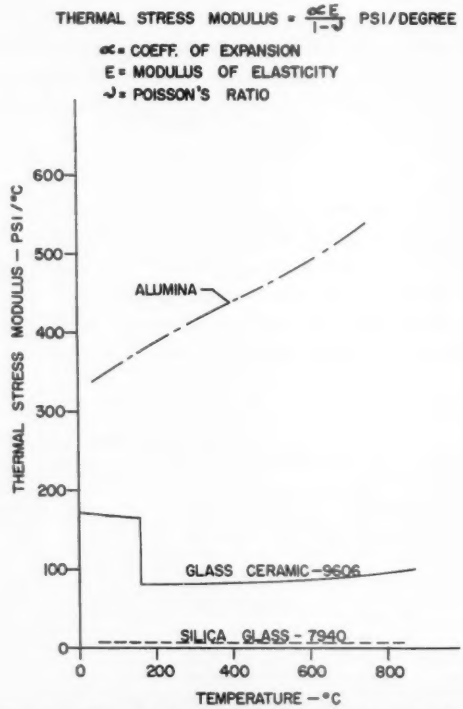


FIG. 5. Thermal stress modulus of ceramic materials.

TABLE 3
Properties of Radome Materials

Material	Thermal Coefficient of Expansion per °C.	Modulus of Elasticity, psi	Poisson's Ratio
Pyroceram 9606	57×10^{-7}	17.3×10^{6}	0.245
Alumina (high density)	73×10^{-7}	40×10^{6}	0.32

Thermal stress moduli for these materials are shown in Fig. 5 in comparison with fused silica.

some extent the shock temperatures attained by Pyroceram 9606 and alumina of Table 2.

Conclusions and Recommendations

(1) The results of this preliminary work indicate that these tests can be used for the evaluation of radome materials subject to thermal shock from the heating of one surface.

(2) Further work should be carried out along these lines. All significant data can be obtained from the test assemblies designated as Cases I, III, and V.

(3) Additional work should include the computation of temperature distribution curves through the wall section under transient conditions. Analog or digital computers can be used for this purpose. Programing of this operation has already been worked out for the digital computer.

General design data relating flight contours to maximum thermal stresses should be computed for ceramic materials being considered for radome applications. Experimental data on total emissivity of these materials are essential for such computations.

The above information will enable the radome designer to choose the material best suited to the desired flight contour.

(4) The tests reported here demonstrate clearly the importance of low values of expansion coefficients in increasing thermal shock resistance.

References

[1] Dusinberre, G. M., *Transactions of American Society of Mechanical Engineers*, Vol. 67, pp. 703–712, 1945.

[2] Schneider, P. J., *Conduction Heat Transfer*, 1st Ed., pp. 292–294; Addison-Wesley Publishing Co., Inc., 1954.

[3] McAdams, W. H., *Heat Transmission*, 3rd Ed., pp. 31–54; McGraw-Hill Book Co., New York, 1954.

[4] Roark, R. J., *Formulas for Stress & Strain*, 3rd Ed., pp. 334–340; McGraw-Hill Book Co., New York, 1954.

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Elemental Boron. . . . . (Continued from page 40)

solid boron. This behavior can be explained by considering the differences in conditions present and the sequence of events during ignition and burning of boron in the form of solid rods and as relatively loose powders.

In both cases, the igniter raises the temperature of the surface boron through an intermediate temperature range (Regions 1–3) while boron oxide builds up on the surface. Continued application of the igniter causes the oxide to evaporate until the then quite hot boron surface is covered with a very thin oxide film (upper portion of Region 3) or is exposed to oxygen directly (Region 4). After removal of the igniter, the reaction rate of the surface boron is then rapid enough to furnish enough heat to maintain its surface at a temperature sufficient to evaporate B_2O_3 as fast as it forms and also to preheat the adjacent boron beneath the surface layer. In the case of a powder, the boron particles adjacent to the surface have by this time a considerable amount of protective oxide coating from both prior reaction with oxygen at intermediate temperatures and by condensation after evaporation from the hotter-burning surface particles. This coating acts as a barrier to continued burning, and the reaction ceases after only a few layers of particles adjacent to the surface have burned. However, in the case of solid boron, the boron beneath the burning surface is preheated through the intermediate temperature range out of contact with the gas phase, so that no protective film of oxide can form by prior reaction or condensation to retard burning later, as in the case of powdered boron.

Anything that will affect the evaporation rate of boron oxide should have an effect on the burning rate of boron in Region 3. Water vapor is known to increase the evaporation rate of boron oxide,[2] and, as expected, we have found the oxidation rate to be about doubled at 1,340°K. by the addition of 1 per cent water vapor to the oxygen. When about 1 per cent silicon was present in the solid boron, evaporation of the boron oxide was retarded in oxygen at one atmosphere, and large droplets of liquid oxide collected on the rod at 1,455°K., thereby causing Region 2 to persist at higher than normal temperatures.

References

[1] Kubaschewski, O., and Hopkins, B. E., *Oxidation of Metals and Alloys*, chapters 1 and 3; Butterworths Scientific Publications, London, 1953.

[2] Margrave, J. L., *Gaseous Molecules of Geochemical Significance*, J. Phys. Chem., Vol. 60, No. 6, pp. 715–717, June, 1956.

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Mortality of Devices. . . . (Continued from page 42)

$$f(t) = [(c\,t - m)^{2n} + a\,]e^{-\int_0^t [(c\,t - m)^{2n} + a]dt}$$

$$= [(c\,t - m)^{2n} + a] \times e^{-\{[1/(2n+1)c](c\,t - m)^{2n+1} + at + [1/(2n+1)c]m^{2n+1}\}}$$

$$= [(c\,t - m)^{2n} + a] \times e^{-[1/(2n+1)c][(c\,t - m)^{2n+1} + m^{2n+1}] - at}$$

This is the corresponding probability density function for the total life.

For predeterminations of the reliability of the device concerned, one needs values of $\int_0^t f(t)dt$. These may be computed without too much labor, with the aid of some of the modern high-speed computing machines.

Man's projects to go higher into space and at greater speeds have made the problem of acceleration an increasingly important one. This report deals with the incorporation of the acceleration forces into the flight simulator.

The Development of Dynamic Flight Simulation

James D. Hardy and Carl C. Clark

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THE VALUE of simulating flight as a training device was recognized prior to World War II. The Link Trainer was one of the earlier flight simulators and it served well the demands for preflight training of Aviation Cadets, saving many hours of airborne flight training and damage to equipment, as well as lives of trainees and instructors. The demand for training during World War II so increased the work load on training aircraft that additional exploration into the field of flight simulation was necessary. Indeed, simulated flight was made so realistic that entire flight crews could be trained with instruments under computer control. Realistic emergencies could be programed, giving instrument indications and even simulated motor sounds which would be characteristic of the flight situation. With the help of such simulators, it was possible during World War II to train, in a few months, the hundreds of thousands of pilots and flight engineers who were required to man combat aircraft.

With the advent of the jet aircraft, complexities of flight have still further increased. Fortunately, the development of flight simulation has been able to match this progress with simulations characteristic of the highest performance aircraft. The unquestioned usefulness of flight simulation as a training device has resulted in the development of the Operational Flight Trainer of the present day. Designed to simulate a particular type of aircraft with a specific type of mission, these flight simulators are transported to various operational bases where they provide pilot trainees with a most realistic type of flight training.

The training aspect of the flight simulator is not the limit of its usefulness. Flight simulators are now built by all airframe manufacturers to evaluate, with experienced test pilots, a proposed aircraft system. These preflight test systems employ the most complex computer control, using wind-tunnel data and control system measurements together with pilot inputs to determine the stability and controllability of the man-

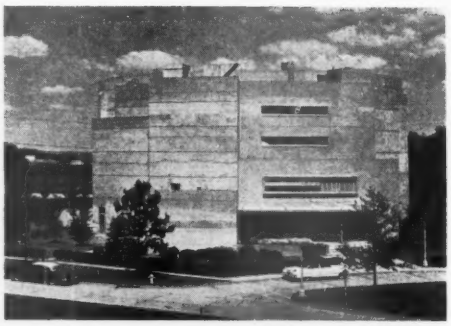

FIG. 1. Centrifuge laboratory at the U.S. Naval Air Development Center, Johnsville, Pa.

aircraft system. The National Aeronautics and Space Administration has played an important role in the development of flight simulation as a preflight test system. Their long preoccupation with research aircraft has made it important for the NASA to develop preflight simulators to a high degree of perfection as the number of flights must be small and the pilot efficiency maximum.

In any simulation, the required compromises with the actual condition of flight place important restrictions on the usefulness of the simulation. No simulation can be more than an approximate reproduction of flight. The compromises that must be accepted are many. In a marginally stable aircraft, less compromise can be accepted, and, in particular, it is desirable to have acceleration inputs to the pilot, in addition to those afforded by indications of instruments. The need for acceleration inputs was mentioned by Pecoraro[1] in 1954 who noted that, "In all simulation experiments, it is understood that some compromise must be made. In this case, it was felt that physiological cues to the inertial forces are missing. But a human centrifuge could be useful for additional study if desired and necessary." It is perhaps safe to say that, until the

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Carl C. Clark received his B.S. degree in Physics from Worcester Polytechnic Institute in 1944, and his Ph.D. in Zoology from Columbia University in 1950. He was Research Associate in Physiology at Cornell Medical College, 1950–51, and Assistant Professor of Zoology at the University of Illinois, 1951–54. In 1954 he was appointed Head, Biophysics Division of the Aviation Medical Acceleration Laboratory, and Associate in Physiology at the University of Pennsylvania School of Medicine. His principal studies include infrared and X-ray diffraction analysis of biochemicals, molecular structure of biological cells, multivariable physiological analysis, and centrifuge dynamic control simulation.

marginally stable aircraft became an important instrument of flight research, the necessity of presenting the pilot with acceleration forces was not clear. However, with the desire of man to go higher into space and at greater and greater speeds, the problem of acceleration became an increasingly important one. It is the incorporation of the acceleration forces into the flight simulator that is the burden of this report. As predicted by Pecoraro, this has involved the use of a human centrifuge.

The Aviation Medical Acceleration Laboratory Centrifuge

The large human centrifuge located at the Naval Air Development Center was designed in the dark days of World War II when the Bureau of Aeronautics (USN) became convinced that the problems of acceleration had to be approached on a long term basis. At this time, small centrifuges had been built in various parts of the country, and it was the desire of the Navy to construct an interservice facility which would meet the requirements of research and development in the field of radial acceleration for many years. The centrifuge laboratory was formally commissioned in 1952.

A view of the cylindrical centrifuge building is shown in Fig. 1. As originally conceived, the building was to house a minimum of laboratories other than the centrifuge chamber itself and was to be available mainly for programs originating outside of the laboratory. The development of the laboratory's program over the years has included, in the limited space available, a comprehensive Aeromedical Laboratory with the disciplines of aviation medicine, biophysics, biochemistry, pathology, physiology, and psychology represented. It is the synthesis of efforts from all of these disciplines that has culminated in the successful development of dynamic flight simulation. Fig. 2 shows a photograph of the centrifuge rotunda.

In Fig. 2 is shown the 50-ft. centrifuge arm, the housing of the 4,000-hp. direct current motor which furnishes the driving power of the centrifuge, and, at the end of the arm, the gondola suspended in its double gimbal system. The outer gimbal permits rotation of the gondola about an axis tangential to the motion of the centrifuge; the inner gimbal allows rotation about an axis at right angles to the tangential motion of the gondola. These two angular motions are controlled by 75-hp. motors connected through special hydraulic drives. At the top of the photograph is shown the control blister supported in the ceiling of the centrifuge chamber. A small swinging platform is shown mounted at the 37-ft. radius of the arm. It was upon these platforms that almost all of the work of the centrifuge for the first 5 years was carried out. This was due to the fact that the difficulties with the control system had not been thoroughly worked out.

The Dynamic Flight Simulator

To understand the dynamic flight simulator, consider briefly the control of the acceleration vector provided by the servosystems of the arm rotation and gimbal positions.

As shown in Fig. 3, the rotation of the centrifuge about its axis at an angular velocity, ω, induces a radial acceleration, A_r. The tangential acceleration A_t is a function of $\dot{\omega}$, the angular acceleration, and when the centrifuge is rotating at constant angular velocity, A_t is zero. A_t is the acceleration of gravity. The resultant of these accelerations is given by the square root of the sum of the squares of the three components. As far as the pilot is concerned, it is convenient to consider the resolution of the acceleration vectors in terms of a_x, a_y, and a_z; a_x being dorsal-ventral acceleration, a_y being lateral acceleration, and a_z, acceleration along the long axis of the body. For simple "positive" g and "negative" g, the resultant acceleration is a_z, and a_x and a_y equal to zero. The resolution is indicated

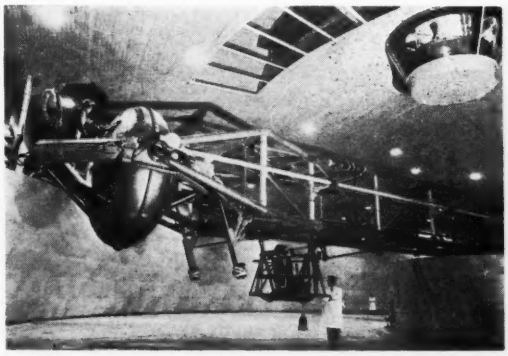
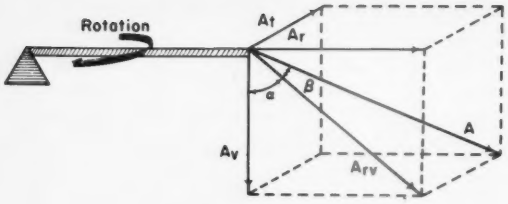


FIG. 2. Centrifuge chamber showing experimental gondola, swinging platform, control blister, motor housing, and the 50-ft. arm.



VECTOR DIAGRAM OF ACCELERATIONS ON CENTRIFUGE

FIG. 3. Vector diagram for accelerations imposed on human subjects. A_t = tangential acceleration; A_r = radial acceleration; A_v = acceleration gravity; A = resultant acceleration; α, β = gimbal angles.

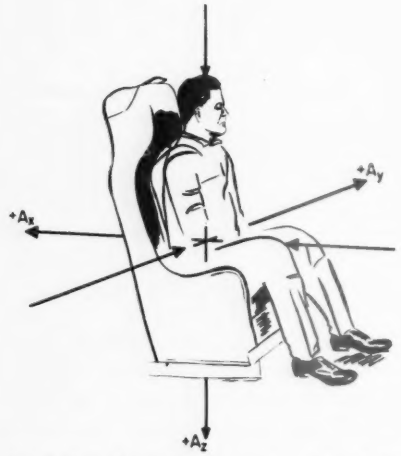


FIG. 4. Resolution of acceleration vector along body axes for physiological studies.

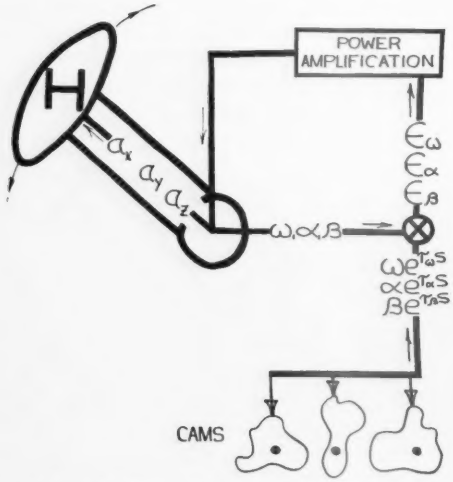


FIG. 5. Schematic diagram of automatic centrifuge control for programed accelerations by use of mechanical cams.

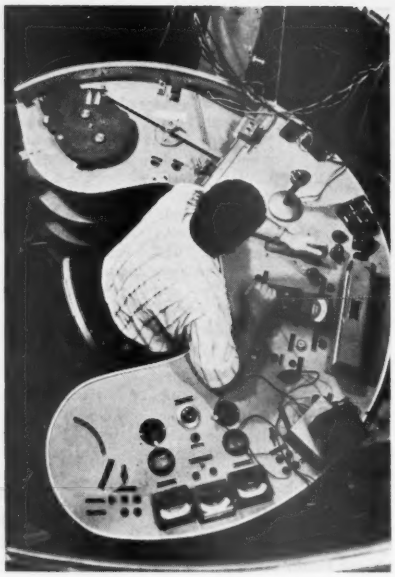


FIG. 6. Operating blister showing emergency safety control and the mechanical cam system.

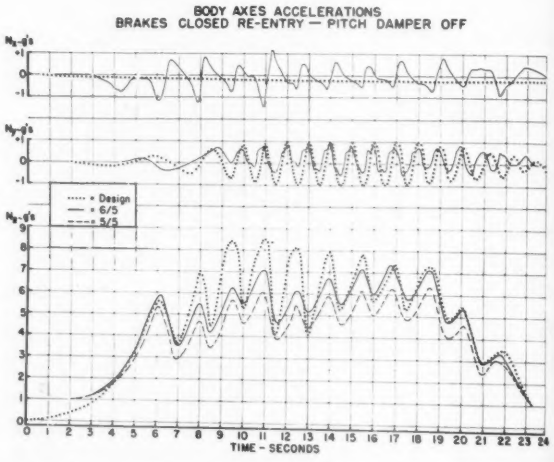


FIG. 7. Programed X-15 accelerations. N_x = lateral acceleration, N_y = back-to-front acceleration, N_z = head-to-foot acceleration.

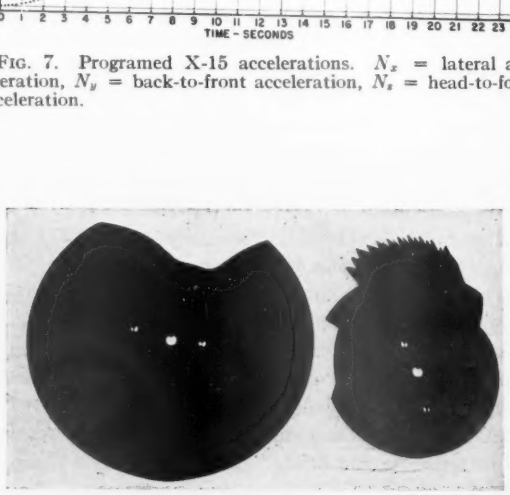


FIG. 8. Control cams for automatic programing of acceleration patterns. At right, X-15 A_z cam; at left, simple positive acceleration cam.

in Fig. 4. Accelerations a_x, a_y, and a_z are functions of the angular velocity ω, and the gimbal angles, α and β. As originally designed, ω, α, and β were programed by mechanical cams, as shown in Fig. 5. Here, H represents the subject in the gondola of the centrifuge, and a_x, a_y, and a_z the physiological accelerations which are desired. The cams, which are large masonite discs, are cut so that the potentiometers associated with the cam followers generate voltages proportional to the desired ω, α, and β. Delay times τ_ω, τ_α, and τ_β are introduced in the cam design in order to take into account the differences in response times of the centrifuge and the gimbal systems. These voltages are fed into the power amplifiers controlling the main power systems, and the responses of the centrifuge and gimbals are returned to the differential servocontrols as ω_1, α_1, and β_1. The errors ϵ_ω, ϵ_α, and ϵ_β are supplied to modify the centrifuge motions. This system has two great advantages over others that have been used for centrifuge control: (a) acceleration inputs can be automatically controlled in all three axes, and are precisely reproducible, and (b) it is possible to program a complex acceleration pattern. Its principal disadvantage lies in its inflexibility and cumbersomeness. The large effort associated with the construction of the cams (some of it trial and error) and the great number of cams required for a single program reduced the usefulness of this system to application in only a few unusual experiments. Fig. 6 shows the manual safety control of the centrifuge with the safety engineer at his console; the cam table is seen to his left. The cam shown in the photograph is the ω cam for the first X-15 experiment.

The X-15 Simulation Program

The most elaborate and extensive of the experiments in which the cams were used was that to determine the tolerance of the pilots to the anticipated accelerations of the X-15 aircraft emergency conditions. Shown in Fig. 7 are the desired accelerations, a_x, a_y, and a_z, as determined by the North American Aviation computer laboratory for a condition of the X-15's re-entry into the atmosphere with the pitch control damper not operating. The first question asked here was whether or not the test pilot could tolerate acceleration of the magnitude anticipated under these extreme conditions. Shown at the top of the figure, a_x was designed to vary between 0 and $-0.2g$. Acceleration a_y was to have an oscillation between $\pm 1g$ with a frequency of about 1 cycle per sec. Acceleration a_z was expected to rise from 0 to a maximum of $8g$ and to oscillate with a frequency of about 0.7 cycles per sec. between 4 and $8g$ for a period of about 12 sec. The dotted lines in the chart indicate the designed accelerations; the solid lines indicate the centrifuge simulation, which for a_y and a_z were considered quite good. There was an undesirable oscillation in a_x. This program was run and found to be near to the physiological tolerance of the test pilot. Even with the best support, petechiae formed on the hands, feet, and back, and, in one experiment, a North American test pilot became unconscious due to a malfunction in the g protection apparatus. To give an idea of the complexity of this simulation, so far as control of the centrifuge is concerned, Fig. 8 shows the ω cam for the acceleration pattern just shown and, for comparison, the ω cam for a high g pullout.

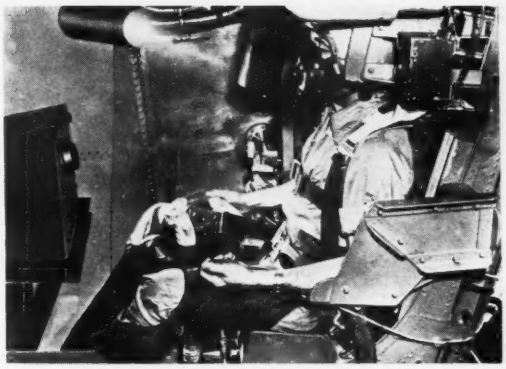


FIG. 9. A view into the gondola—the subject performing tracking task.

The complexity of the acceleration patterns to be reproduced was moving beyond the ability of mechanical cam control. At the present time, cam control has been replaced by a punched tape control of greater precision and flexibility.

Among the questions asked in the first X-15 study with the acceleration pattern just described was the degree of degradation of pilot performance which would occur as a result of the acceleration inputs. In this study, an oscilloscope was mounted in the gondola of the centrifuge and the pilot performance with the conventional center stick and with a right-hand console stick was measured. Fig. 9 shows the gondola installation for this study, with the subject sitting in place facing the oscilloscope on which was programed the tracking task. In addition to the performance information, physiological data including electrocardiograms were recorded on an oscillograph. The results of this experiment indicated that even under extreme conditions there was a large degradation of performance although the pilot could tolerate the imposed accelerations. There were also indications that control with the side-arm console stick was more effective than with the center control stick. Undoubtedly, the most important result of this series of experiments was the realization that the centrifuge had sufficient flexibility to be used as a dynamic flight simulator. The flight simulator is illustrated diagrammatically in Fig. 10. The pilot in the gondola is indicated facing the instrument display and operating the control system to execute a flight mission. The pilot's control motions are fed into a large computer which changes the instrument indications to show to the pilot his progress through a maneuver. This closed loop is, of course, that which is present in the usual fixed base flight simulator. The control motions of the pilot, together with the aerodynamic equations of the aircraft, are also used in computing accelerations. These signals are converted

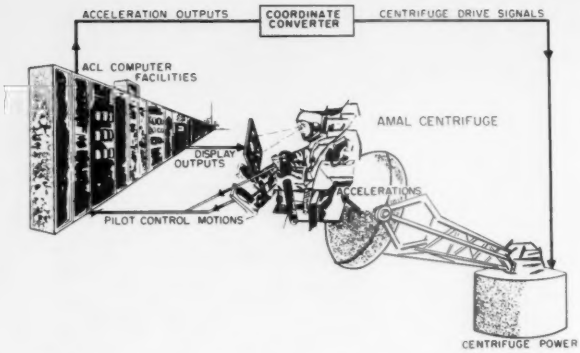


FIG. 10. Diagrammatic representation of centrifuge operating in connection with Aeronautical Computer Laboratory as a dynamic flight simulator.

through a coordinate transformation system and compensating network into drive signals to the centrifuge. This is illustrated in Fig. 11.

The subject, *H*, in the gondola, who is viewing the instrument display, makes control motions which are transmitted to the computer resulting in acceleration demands and alterations in instrument display. The instrument closed loop computes roll, pitch, yaw, air speed, and altitude. Subsequent simulations involve computer drives for most of the flight instruments. In parallel with this, accelerations a_x, a_y, and a_z are computed and, after transformation by the conversion system, result in ω, α, and β signals which, when corrected for response times, feed into the differential servocontrol of the centrifuge. These signals drive the centrifuge in such a way that the pilot receives a good approximation of the acceleration he would receive in actual flight in this aircraft had he made the same control motions. The centrifuge has, however, only 3 degrees of freedom of motion—1 in the main arm and 2 in the gimbal system—whereas the aircraft has 6 degrees of freedom—3 of rotation and 3 of translation. The

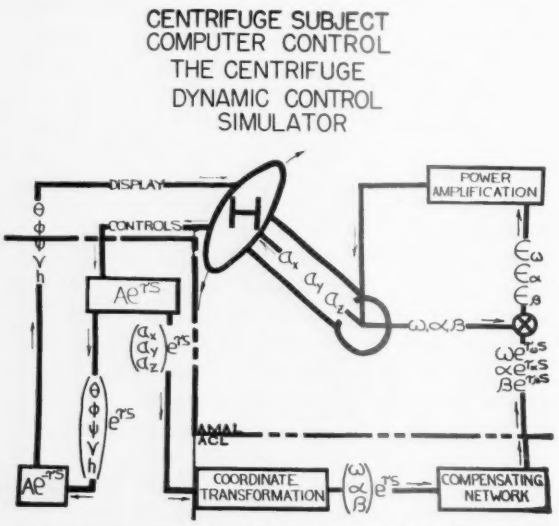


FIG. 11. Schematic diagram of centrifuge closed loop control. θ = roll angle; ϕ = pitch angle; ψ = yaw angle; A = analog; V = air speed; h = altitude; τ = instrument delay time; and S = transform function.

centrifuge is thus limited in its capability of simulating aircraft accelerations.

Perhaps just as important a limitation is our lack of experience with the technique of dynamic flight simulation. To give a simple illustration: an attempt was made to simulate a high *g* pullout from a dive maneuver in which the pilot is experiencing acceleration mainly along the long axis of the body. It had been our custom, when programing such a dive, to start the centrifuge by tilting the gondola forward, out, and then back so that the only linear acceleration was a_z. In this situation, the pilot rode the centrifuge as a passenger. When asking pilots to fly the centrifuge through a pullout using instruments, they had strong reaction against the tilting forward motion because the expected response to the control motion in the aircraft would have resulted in tipping back. This indicated clearly the importance of angular acceleration as well as linear acceleration in flight simulation. However, it was possible to overcome this difficulty very simply. When the centrifuge was run backwards and the pilot tilted backward, outward, and returned, the difficulty just mentioned was avoided.

Discussion

It is quite clear that having the subject ride the centrifuge as a passenger is vastly different from having the subject fly the centrifuge as a pilot. Our real problem at this point is a careful evaluation of the centrifuge as a dynamic flight simulator. We must know when angular acceleration is more important than linear acceleration, and vice versa. We must know more about the interaction of these accelerations. This is a human engineering task of the first order of magnitude of difficulty. We are at the present under way in cooperation with NASA to begin to evaluate the relative importance of angular and linear acceleration in flight and on the centrifuge. A fully instrumented aircraft has been made available, and test pilots will fly through prescribed maneuvers. The equations of the aircraft will be mechanized on the computer and the same test pilot will fly the centrifuge through the same patterns. Measurements will be made of tracking performance and evaluation will be made by the pilot of the faithfulness of the simulation of flight achieved.

At this time, when we are reaching forward to the border of space, much more simulation of flight will have to be done than heretofore. Actual flights may be relatively few, and preflight training in simulators will be long and arduous. The introduction of acceleration into the problem of flight simulation is another step in the steady advance of aviation medicine and human engineering in providing the best possible training for pilots and also in providing a tool for the evaluation of the pilot-aircraft integrated system.

Reference

[1] Pecoraro, J., *The Use of an Operational Flight Trainer as a Research Tool for Aircraft Instrumentation and Cockpit Rearrangement*, Aeronautical Engineering Review, Vol. 13, No. 5, pp. 86–93 May. 1954.

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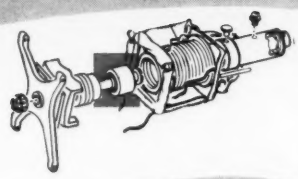
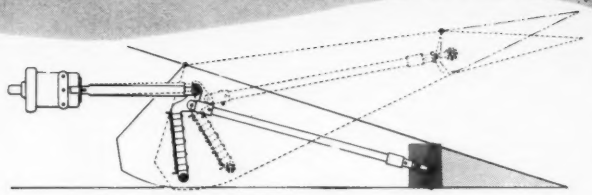
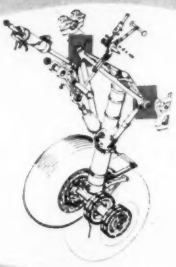


Elevator flight controls



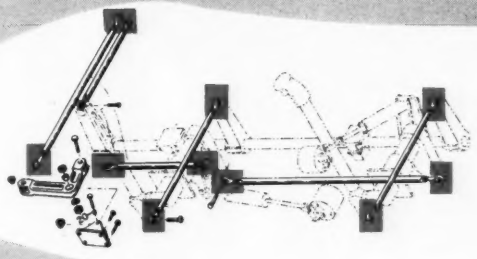
Aileron trim and servo tab control system



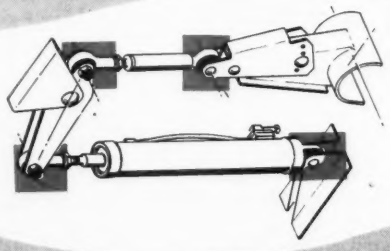
Main landing gear fulcrum and linkage

Wing flap hinge and linkage

Aileron hinge



Helicopter flight control group



Hydraulic actuator linkage

Helicopter blade pitch control link

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Acoustics, Sound, Noise

The Effective Dynamic Parameters for Sound Propagation in Inhomogeneous Media. I. M. Khaikovich and L. A. Khalfin. *Sov. Phys. - Acous.*, July-Sept., 1958, pp. 280–286. Translation. Investigation of the effect of inhomogeneities, distributed in a homogeneous medium in the form of a rectangular lattice, on the dynamic parameters which characterize the propagation of sound waves.

Survey of Hearing in a Low Industrial Noise-Level Population. Appendix A—Pure-Tone Audiometer Calibration Procedures. Appendix B—Speech Audiometer Calibration Procedures. J. F. Corso. *USAF WADC TR 58-442 [AD 204799]*, Oct., 1958. 102 pp. 58 refs.

Some Fundamental Problems in Contemporary Molecular Acoustics: Survey. I. G. Mikhailov, V. A. Solov'ev, and Iu. P. Syrnikov. *Sov. Phys. - Acous.*, July-Sept., 1958, pp. 215–226. 57 refs. Translation.

Attenuation of a Sound Beam Upon Traversing a Layer of Discontinuity in the Velocity of Sound. A. N. Barkhatov and I. I. Shmelev. *Sov. Phys. - Acous.*, Apr.-June, 1958, pp. 125–127. Translation.

The Connection of Acoustic Streaming with Absorption. A. I. Ivanovskii. *Sov. Phys. - Acous.*, Apr.-June, 1958, pp. 142–152. Translation. Presentation of a method for obtaining the stream equations in various media which are described by the Navier-Stokes equation; this is done by means of relaxation hydrodynamics and the theory of recollective media. The equations obtained show that the streaming effect is connected with the presence of the total absorption coefficient and that the frequency dependence of stream velocity is completely defined by the frequency dependence of this coefficient.

On the Absorption of Sound Waves of Finite Amplitude; A Survey. K. A. Naugolnykh. *Sov. Phys. - Acous.*, Apr.-June, 1958, pp. 115–124. 20 refs. Translation.

K Voprosu o Potokakh, Vyzvannykh Zvukom. K. A. Naugol'nykh. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 1,003–1,005. 10 refs. In Russian. Study of sound generated flows in absorbing media for Re $\gtrsim 1$.

Acoustical Design for Transport Helicopters. L. N. Miller, L. L. Beranek, and Harry Sternfeld, Jr. (*AHS J.*, Oct., 1957, pp. 4–28.) *Noise Control*, Mar., 1959, pp. 6–12.

Noise Characteristics of Some Jet Ground Operations. R. M. Hoover and L. N. Miller. (*ASA 55th Meeting, Wash., May 10, 1958.*) *Noise Control*, Mar., 1959, pp. 28–31, 47. Presentation of noise measurements of various ground operations for the Caravelle and Comet 4. During static operations, noise data were obtained at various directions and distances about the aircraft with the engines operating at take-off, climb, taxi, and idle conditions, and during actual take-off operations.

Noise Control for Convair 880 and 600 Jets. R. J. Koenig. *Noise Control*, Mar., 1959, pp. 23–27, 50. Discussion of noise suppressor development and comparison of the 880 and 600 noise spectra with other aircraft. Consideration is given to fly-over and ground run-up noise, and its effect on aircraft performance.

Sound Diffraction by an Unbounded Thin Elastic Cylindrical Shell. L. M. Liamshev. *Sov. Phys. - Acous.*, Apr.-June, 1958, pp. 161–167. 11 refs. Translation. Analysis of the scattering of plane acoustic waves by a thin unbounded elastic cylindrical shell of circular cross section. The solution establishes that vibrations of the shell can lead to an effective variation in the polar scattering characteristic and in the magnitude of the dissipated power, compared to the scattering from an absolutely rigid cylinder with the same dimensions as the shell.

Aerodynamics, Fluid Mechanics

Aerothermodynamics

Thermal Analysis of Stagnation Regions with Emphasis on Heat-Sustaining Nose Shapes at Hypersonic Speeds. A. J. Hanawalt, A. H. Blessing, and C. M. Schmidt. (*Heat Transfer & Fluid Mech. Inst., Berkeley, June 19–21, 1958.*) *J. Aero/Space Sci.*, May, 1959, pp. 257–263. Study of radiation cooling, including the mechanism of conduction, indicates that the heat-sustaining leading edge is practical. For reasonable values of conductivity, the maximum equilibrium temperatures can be reduced to an acceptable level for presently available heat-sustaining materials.

Similitude Treatment of Hypersonic Stagnation Heat Transfer. D. E. Rosner. *ARS J.*, Mar., 1959, pp. 215, 216. AFOSR-supported development of an expression for the convective heat transfer rate at the nose of a blunt body for dissociated but "chemically frozen" laminar flow with arbitrary surface catalytic activity, using the "similarity" between heat and mass transport.

Boundary Layer

Boundary-Layer-Transition Measurements on Hemispheres of Various Surface Roughnesses in a Wind Tunnel at Mach Numbers from 2.48 to 3.55. Angelo Bandettini and W. E. Isler. *U.S., NASA Memo. 12-25-58A*, Mar., 1959. 29 pp.

Effect of the Force of Gravity on the Motion in a Laminar Boundary Layer in Longitudinal Flow of a Gas Around a Plate. A. A. Tanaev. *Sov. Phys. - Tech. Phys.*, Apr., 1958, pp. 805–813. Translation. Presentation of a method for calculating the change in the drag coefficient due to the force of gravity, based on the solution of the equations of motion. The results are crude but give an order-of-magnitude estimate when the method of expansion of powers of a small parameter cannot be applied.

Control Surfaces

Rudder Kick Maneuver Study. II—Analysis of Vertical and Horizontal Tail Load Data Obtained During Rudder Kick and Steady Sideslip Flight Test Maneuvers. J. C. O'Hara. *USAF WADC TR 6743, Pt. II [AD 130900]*, July, 1957. 125 pp. 14 refs.

Flow of Fluids

Fluid Dynamics. A. K. Oppenheim, C. V. Sternling, C. A. Sleicher, Jr., and R. A. Stern. *Ind. & Eng. Chem.*, Mar., 1959, pp. 437–452. 329 refs. Review of recent literature on equations of motion and stability, turbulence, vortex flow and rotation, jets and wakes, flow near solid surfaces, multiphase and free boundary flow, gas dynamics, wave dynamics, dynamics of reactive fluids, and dynamics of conducting fluids.

Generalized-Newtonian Theory. E. S. Love. *J. Aero/Space Sci.*, May, 1959, pp. 314, 315. Comparison of Newtonian and generalized-Newtonian flow with exact solutions for flow over an ogive.

K Voprosu o Nestatsionarnykh Ploskikh Techeniiakh Politropnogo Gaza s Priamolineinymi Kharakteristikami. A. F. Sidorov and N. N. Ianenko. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 832–834. In Russian. Presentation of a classification scheme for unsteady two-dimensional flow of polytropic gas with rectilinear characteristics. It is concluded that in the class of adiabatic motions of gas ($\gamma \neq 2$) there are no vortex flows different from general waves and conical flows.

The Hypersonic Viscous Effect on a Flat Plate with Finite Leading Edge. A. G. Hammitt. (*Princeton U. Dept. Aero. Eng. Rep. 378*, Mar., 1957.) *J. Fluid Mech.*, Feb., 1959, pp. 242–256. 22 refs.

Flight Investigation of the Surface Pressure Distribution and Flow Field Around an Elliptical Spinner. L. P. Thomas, III. *U.S., NASA Memo. 1-26-59L*, Feb., 1959. 10 pp. Investigation covering a Mach Number range from 0.65 to 0.95, which corresponds to a Reynolds Number range from 1.6×10^6 to 3.9×10^6 per ft. Results show that the local Mach Number was less than the free-stream Mach Number in the propeller plane, but free-stream conditions were approached from about 15 to 90 per cent of the spinner length.

Definitions to be Used in the Description and Analysis of Drag; Report of the Definitions Panel. Appendix—Definitions of Certain Terms Used in the Description and Analysis of Drag. (*Gt. Brit., ARC CP 369*, 1958.) *RAeS J.*, Nov., 1958, pp. 796–801.

Hypersonic Aerodynamics. II. W. D. Hayes. *Astronautics*, Apr., Pt. I, 1959, pp. 34, 35, 83, 84, 86. Presentation of a classification for slender winged bodies and development of suitable simplifications in hypersonic flow theory. Total heat transfer is considered.

Influence de l'Hystérèse Capillaire sur l'Ecoulement d'un Liquide—Cas des Oscillations dans un Tube en U; Application aux Métaux Fondus. Huetz-Aubert and J. Huetz. *France, Min. de l'Air PST 347*, 1958. 107 pp. 19 refs. SDIT, 2, Av. Porte-d'Issy, Paris 15, Frs. 1,990. In French. Survey of theoretical and experimental investigations emphasizing the discrepancy between theory and practice. Includes study of the influence of capillary hysteresis on liquid flow covering the case of oscillations in a U-tube. Application is made to the case of molten metals.

Ob Isparenii Sharikov Tverdykh Tel v Potoke Gaza. V. I. Zubkov. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 803–805. In Russian. Study covering the speed of evaporation of solid droplets on a sphere in a flow of gas, taking into account the temperature variation.

The Prospects for Magneto-Aerodynamics—Correction and Addition. E. L. Resler, Jr., and W. R. Sears. *J. Aero/Space Sci.*, May, 1959, p. 318.

Impossibility of Rarefaction Shock Waves in Magnetohydrodynamics. R. V. Polovin and G. Ia. Liubarskii. (*Zhurnal Teoret. i Exper. Fiz.*, Aug., 1958, p. 510.) *Sov. Phys. - JETP*, Feb., 1959, pp. 351, 352. Translation.

On the Flow of a Hydromagnetic Fluid Near an Oscillating Flat Plate. R. S. Ong and J. A. Nicholls. *J. Aero/Space Sci.*, May, 1959, pp. 313, 314. Extension of Rossow's method for flow near an infinite flat wall which executes linear harmonic oscillations parallel to itself. The velocity profile is found for two cases: (1) the magnetic lines of force fixed relative to the fluid, (2) the magnetic lines of force fixed relative to the plate.

One-Dimensional Flow of an Ionized Gas Through a Magnetic Field. R. M. Patrick and T. R. Brogan. (*Avco Res. Lab. RR 13*, Oct., 1957.) *J. Fluid Mech.*, Feb., 1959, pp. 289–309.

The Matching of the Viscid and Inviscid Regions for the Stagnation Magnetic Flow. P. S. Lykoudis. *J. Aero/Space Sci.*, May, 1959, pp. 315–317. Development of a relation between inviscid magnetic flow and the magnetic boundary layer. Using this relation, the intensity of the magnetic field at the stagnation point is calculated in terms of flow parameters and the nondimensional heat-transfer parameter.

On the Oscillations of an Electron Plasma in External Electric and Magnetic Fields. K. N. Stepanov and V. S. Tkalich. *Sov. Phys. - Tech. Phys.*, Aug., 1958, pp. 1,649–1,659. Translation. Analysis of the propagation of electromagnetic waves in a plasma acted upon by crossed electric and magnetic fields, taking into account the effects of the thermal motion of the electrons.

Electron Energy Distributions in Plasmas. I. R. L. F. Boyd and N. D. Twiddy. *Royal Soc. (London) Proc., Ser. A*, Feb. 24, 1959, pp. 53–69. 23 refs. Experimental investigation of electron energy distribution carried out in a variety of striated discharges. It is found that the energy distribution takes the form of two well-separated groups of electrons with, sometimes, a very small third group. The high-energy group is generated by the potential difference across the striation head and becomes progressively attenuated toward its tail.

Laminar Flow in Magnetically Focused Cylindrical Electron Beams. J. L. Palmer. *U. Calif. Inst. Eng. Res., Ser. 60/1217 (AFOSR TN 58-990) [AD 205908]*, Nov. 20, 1958. 25 pp. Development of a general theory applicable to any laminar flow in a cylindrical beam. By numerical integration of the equations of motion the maximum and minimum radii of excursion and the wave length of the undulations for each electron are presented in graphical form for various boundary conditions on the electron beam.

On the Periodic Fundamental Solutions of the Stokes Equations and Their Application to Viscous Flow Past a Cubic Array of Spheres. H. Hasimoto. *J. Fluid Mech.*, Feb., 1959, pp. 317–328. 20 refs. Solution of the Stokes equations of motion by means of a Fourier series. As an application of these solutions the force acting on any one of the small spheres forming a periodic array is considered. Cases for three special types of cubic lattice are investigated.

The Steady Flow of Viscous Fluid at Low Reynolds Numbers Passing Obliquely Through a Plane Grid Made of Equal Parallel Circular Cylinders. Kô Tamada and Hiroomi Fujikawa. *Phys. Soc. Japan J.*, Feb., 1959, pp. 202–216. Theoretical analysis of the flow problem based on the Oseen approximation. Explicit expressions are derived for the force acting on a cylinder, the velocity at a downstream infinity, and the angle of flow deflection. Transition from the Oseen to the Stokes approximation is discussed.

The Slow Motion of Two or More Spheres Through a Viscous Fluid. G. J. Kynch. *J. Fluid Mech.*, Feb., 1959, pp. 193–208. Derivation of expressions for the velocity of two spheres, moving slowly under external forces through a viscous fluid, as a function of their separation and radii. A discussion of the interactions of three particles and some general comments on the settling of a swarm of spheres are also included.

Some Remarks on the Structure of Shock Waves. G. S. Golitsyn and K. P. Staniukovich. (*Zhurnal Teoret. i Exper. Fiz.*, Sept., 1958, pp. 828–830.) *Sov. Phys. - JETP*, Mar., 1959, pp. 575, 576. Translation. Qualitative investigation of some aspects of the physical structure of a normal shock wave in magnetohydrodynamics.

Phenomenological Equations of Statistical Dynamics of an Incompressible Turbulent Liquid. B. I. Davydov. (*Zhurnal Teoret. i Exper. Fiz.*, Aug., 1958, pp. 527–529.) *Sov. Phys.-JETP*, Feb., 1959, pp. 364, 365. Translation. Development of a closed system of differential equations by limiting the number of variables that characterize the motion of the liquid. These are the mean velocity at a given point, the mean pressure, the second moments of the fluctuating velocity, and the turbulent viscosity.

Theoretical Derivation of Tangential Velocity Profiles in a Flat Vortex Chamber—Influence of Turbulence and Wall Friction. K. Rietema and H. J. Krajenbrink. *Appl. Sci. Res., Sect. A*, No. 2-3, 1959, pp. 177–197. Description of the theoretical approach to the problem and evaluation of experimental results.

Internal Flow

An Approximate Solution for Transonic Flow in Cascades. A. D. Wood and J. H. Clarke. *J. Aero/Space Sci.*, May, 1959, pp. 318, 319. AFOSR-supported presentation of a simple method for the solution of isentropic flow in a cascade, and comparison with the method of Spreiter and with experimental data.

Supersonic Ramjet Diffuser Design. R. B. Pearce, Jr. *Astronautics*, Apr., Pt. I, 1959, pp

46–48, 68, 71. Discussion of the objectives and design characteristics of the ramjet diffuser. Problems such as airflow stabilization and internal inlet contraction are considered.

On Turbulent Flow in the Entrance Length of a Straight Tube of Circular Cross-Section. G. V. Filippov. *Sov. Phys. - Tech. Phys.*, Aug., 1958, pp. 1,681–1,686. Translation. Presentation of a method of calculation for the flow in the inlet portion of a tube assuming a logarithmic law for the velocity profile.

Aerodynamic Theory of the Annular Jet. I. G. D. Boehler and R. J. Spindler. (*IAS 27th Annual Meeting, Jan. 26–29, 1959, Rep. 59-77.*) *Aerophys. Co. Rep. AR 581-R*, Dec., 1958. 150 pp. 37 refs.

Experimental Investigation of Coaxial Jet Mixing of Two Subsonic Streams at Various Temperature, Mach Number, and Diameter Ratios for Three Configurations. R. R. Burley and Lively Bryant. *U.S., NASA Memo. 12-21-58E*, Feb., 1959. 29 pp. Presentation of experimental results in the form of curves of velocity and temperature profiles across the radius for various stations along the mixing zone.

On the Breaking Up of a Fluid Jet Into Drops. P. I. Kuznetsov and L. Ia. Tslaf. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,135–1,138. 10 refs. Translation. Study of factors which give rise to the dispersion of the sprayed portion of the jet. It is shown that the mean dimensionless drop diameter is dependent on two dimensionless parameters, the Froude Number and one represented by gD^3/ν_f^2 (where g is the gravitational acceleration, ν_f is the kinematic viscosity of fluid and D the diameter of the nozzle).

Stability & Control

Rolling Pullout Study. I—Development of a Large Disturbance Theory for Calculating Airplane Motions and Tail Loads in a Rolling Pullout Maneuver. III—Comparison of Calculated and Measured Airplane Motions and Tail Loads During Typical Rolling Pullout Maneuvers. D. W. Rhoads and J. C. O'Hara. *USAF WADC TR 57-01, Pts. I, III [AD 130877; AD 130878]*, July, 1957. 99; 76 pp. 29 refs.

Wings & Airfoils

The Problem of Obtaining High Lift-Drag Ratios at Supersonic Speeds. C. E. Brown and F. E. McLean. (*IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958, Preprint 844.*) *J. Aero/Space Sci.*, May, 1959, pp. 298–302. 17 refs. Analysis concluding that high aspect ratio wings still offer the best hope for substantial reductions in drag due to lift.

Ein einfaches Traglinienverfahren zur Berechnung der Auftriebsverteilung an gepfeilten Flügeln. Boris Laschka and Friedrich Wegener. *ZFW*, Feb., 1959, pp. 39–45. In German. Description of a simple method for calculating the lift distribution of sweptback wings, especially for large aspect ratios such as those of long-range aircraft and gliders.

Theory of Thin Airfoils in Fluids of High Electrical Conductivity. W. R. Sears and E. L. Resler. (*Cornell U. Grad. Sch. Aero. Eng. Rep.*, Aug., 1958.) *J. Fluid Mech.*, Feb., 1959, pp. 257–273. USAF-Navy-supported study.

Aeroelasticity

Analysis of Acceleration, Airspeed, and Gust-Velocity Data from a Four-Engine Transport Airplane Operating Over a Northwestern United States-Alaska Route. J. N. Engel and M. R. Copp. *U.S., NASA Memo. 1-17-59L*, Feb., 1959. 15 pp.

The Use of Models in Aeroelastic Analysis. J. A. McKillop. (*CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 850.*) *Can. Aero. J.*, Mar., 1959, pp. 89–98.

Research Into the Best Excitation for the Natural Modes of a Structure. J. Leclerc. (*France, ONERA MT 1*, 1958.) *Gt. Brit., RAE Lib. Transl. 784*, Oct., 1958. 11 pp.

Note on the Systematisation of the Calculation of the Natural Vibrations of a Free Structure. R. Kappus and D. Clerc. (*France, ONERA MT 2*, 1958.) *Gt. Brit., RAE Lib. Transl. 785*, Nov., 1958. 10 pp.

Note on the Determination of Higher Modes of Vibration by the Stodola or Matrix-Iteration Method. H. E. Fettis. *J. Aero/Space Sci.*, May, 1959, pp. 317, 318. Presentation of a method for eliminating the lower modes in the iteration process without the complication of the orthogonalization process.

Special Issue: Colloquium on Mechanical Impedance Methods for Mechanical Vibrations. *Noise Control*, Mar., 1959, pp. 32–39. 41 refs. *Contents:* I—**Introduction to Mechanical Impedance Methods for Vibration Problems.** R. Plunkett. I—Discussion which includes the history, definitions, and applications to mixed systems (combined mechanical, electrical, and acoustical) and homogeneous systems, along with a summary of the methods. II—**Impedance and Mobility Analysis of Lumped Parameter Systems.** S. H. Crandall. III—**Impedance Analysis of**

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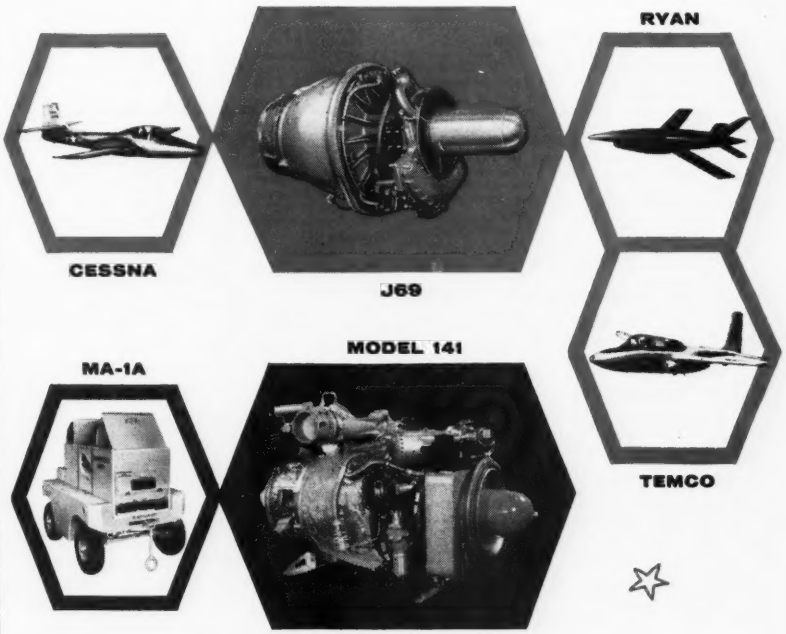

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Aeronautics, General

Report on Japan's Aircraft Industry. I, II. John Fricker. *The Aeroplane*, Mar. 6; 13, 1959, pp. 279–283; 307–311. Survey by individual company of the progress in aircraft development since the end of World War II.

Air Transportation

Freighters—A General Survey. E. D. Keen. *RAeS J.*, Mar., 1959, pp. 135–146; Discussion, pp. 146–152. Discussion on the use of freighter aircraft, covering factors such as freighting prospects, the various advantages of air freighting, aircraft design, and freight handling.

The Helicopter—An Adjunct to Fixed Wing Travel. Jack Slattery. *AHS Newsletter*, Mar., 1959, pp. 2–8. Discussion on the development and the operation of the New York Airways' helicopter fleet.

Airplanes

Air Conditioning, Pressurization

In the DC-8: Air Conditioning the "Pilot's Office." W. W. Reaser. *Air Line Pilot*, Mar., 1959, pp. 5–7, 10, 11.

Cockpits, Canopies, Windshields

Design Manual for Windshield Jet Air Blast Rain and Ice Removal. H. R. Meline and I. D. Smith. *USAF WADC TR 58-444 [AD 208282]*, Nov., 1958. 476 pp. Test results indicating that a jet air blast system is an effective method of providing improved vision under rain and icing conditions over a broad range of flight velocities. Design criteria are presented in the form of curves, sketches, and photographs to illustrate the relative and absolute effect of all variables on windshield visibility.

Are Airliner Flight Decks Good Enough? *Air BP*, No. 10, 1959, pp. 2–6. Discussion of various flight deck shortcomings and possible improvements.

Control Systems, Automatic Pilots

Operation of Autopilot Servo Actuators. R. K. Smyth. *Appl. Hydraulics & Pneumatics*, Mar., 1959, pp. 110, 112, 113. Description of three types of hydraulic autopilot servos — the series, parallel, and dual input types. Advantages and limitations of each are discussed.

The Role of Electrical Actuating Systems in Supplementing SeaMaster Flight Controls. H. C. Zachmann. *(CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 846.) Can. Aero. J.*, Mar., 1959, pp. 83–88.

Description

Superiority Through Simplicity. H. U. Tsakis. *Interavia*, Mar., 1959, pp. 282, 283. Design characteristics and production methods of the Grumman F11F-1F Super Tiger.

Drone Aircraft. H. G. Conway. *RAeS J.*, Mar., 1959, pp. 163–174. Survey covering the purposes and existing types of target aircraft, missile problems affecting target choice, aircraft guidance and control, instrumentation, and some future problems.

A Joint Japanese Transport. *The Aeroplane*, Mar. 6, 1959, pp. 284–286. Design and performance characteristics of the YS-11 transport powered by two Rolls-Royce Dart power plants.

The Engineering Development of Turbine Aircraft as Influenced by World Traffic Patterns. II. D. J. Lambert. *SLAE J.*, Feb., 1959, pp. 2–14. Structural and system characteristics of the Vanguard propjet transport.

"Mission Concept"—The Electra Philosophy. C. F. Schmidt. *(ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958.) Mech. Eng.*, Apr., 1959, pp. 56–59. Description of the characteristics of aircraft designed to meet specific service requirements, and discussion of various surveys and tests leading to the final configuration.

Some Notes on Pressure-Cabin Design. P. B. Walker. *(Aircraft Eng.*, Sept., 1958, pp. 272–276.) *Gt. Brit., RAE Rep. Struc. 242*, Nov., 1958. 21 pp.

Transport Aircraft Developments. Harold Hoekstra. *Aero/Space Engrg.*, May, 1959, pp. 41–43. Brief survey of the work done to establish airworthiness standards for aircraft used in United States civil operation.

Supersonic Air Transport. Molly Neal. *Flight*, Mar. 13, 1959, pp. 348–351. Discussion of the results of an IAS forum on supersonic transports and their significance as applied to the British industry.

Landing, Landing Loads

Flight Evaluation of Visual Approach Angle Indicators. F. J. Burke. *USAF WADC TN 58-181 [AD 155676]*, July, 1958. 32 pp. Presentation of data obtained from flight evaluation of five systems. The WADC Two-Bar System and the Navy Mirror Landing System are shown to afford the most approach angle aid to pilots.

Landing Gear

Design of Liquid-Spring Shock Absorbers for Landing Gear. Edward Mucha. *Appl. Hydraulics & Pneumatics*, Mar., 1959, pp. 114, 116, 117. Discussion of three basic designs emphasizing hydraulic considerations for proper operation.

Operating Characteristics, Economics

Mach 3-5 Airliners Look Economically Feasible. J. L. Jones and D. H. Dennis. *Space/Aeronautics*, Apr., 1959, pp. 41–43. Analysis of the economics of flight at supersonic and hypersonic speeds for commercial air transports. Probable trends in airframe weight, power-plant efficiency, and aerodynamics are discussed and used to estimate relative fleet costs up to speeds of Mach 12.

Airports

The Airports of Britain. Roy Allen. *Aeronautics*, Apr., 1959, pp. 46–52. Survey of the principal airports and their relative importance, and a description of development work.

Mineral-Free Water—A New Ground Service for Turbojets. Ch. F. Raines. *Aero/Space Engrg.*, May, 1959, pp. 53–56. Discussion of the additional thrust of water-injection systems required by turbojets at take-off. Water purity and the need for deionizing units are considered.

Aviation & Space Medicine

Aviation Medical Safety Training: Procedures, Findings, and Recommendations. J. F. Parker, H. E. Price, J. T. McLaughlin, W. P. Shanahan, and Harry Older. *U.S., NTDC TR 1339-28-1*, Aug. 31, 1957. 41 pp.

Aviation Medical Safety Training: Course Content Materials for Training Naval Flight Surgeons. J. F. Parker, Jr., H. E. Price, J. T. McLaughlin, W. P. Shanahan, and Harry Older. *U.S., NTDC TR 1339-28-2*, Aug. 31, 1957. 319 pp. 12 refs.

Aviation Medical Safety Training: Recommended Training Aids and Devices. J. F. Parker, Jr., H. E. Price, J. T. McLaughlin, W. P. Shanahan, and Harry Older. *U.S., NTDC TR 1339-28-3*, Aug. 31, 1957. 38 pp.

Medical Aspects of Interdynamic Adaptation in Space Flight. L. E. Lamb. *J. Av. Med.*, Mar., 1959, pp. 158–161. Discussion of some acute problems in the respiratory and circulatory systems of the body which must be considered on an individual basis in conjunction with rocket flight.

Survival in Space. James Ryan. *Air BP*, No. 10, 1959, pp. 31–34. Discussion of manned space travel requirements and of possible means of solution.

Correlation of Heart-Brain Distance and of Sitting Height Against Positive Acceleration Thresholds. S. Hunter. *Gt. Brit., FPRC 1048*, Apr., 1958. 4 pp.

Human Tolerance to Some of the Accelerations Anticipated in Space Flight. Stuart Bondurant, N. P. Clarke, W. G. Blanchard, Hugh Miller, R. R. Hessberg, Jr., and E. P. Hiatt. *USAF WADC TR 58-156 [AD 151172]*, Apr., 1958. 15 pp. 10 refs. Study of the capacity of human subjects to withstand repeated peaks of acceleration similar to those encountered in multistage rocket vehicles. Tolerance times longer than any previously reported are obtained by immersion of the subject in water in the semisupine position.

Stress Summation in Flight. V—The Effect of Insulin Hypoglycaemia on Tolerance to Acceleration. M. K. Browne. *Gt. Brit., FPRC 1044*, May, 1958. 9 pp. 21 refs.

Stress Summation in Flight. IV—The Effect of Hyperglycaemia on Tolerance to Acceleration. M. K. Browne. *Gr. Brit., FPRC 1041*, Mar., 1958. 3 pp.

Skin Resistance Changes During Acceleration. S. I. Cohen, A. J. Silverman, G. D. Zuidema, and G. E. Johnson. *USAF WADC TN 56-397 [AD 97275]*, Apr., 1958. 10 pp. Discussion of preliminary findings using the skin resistance to evaluate response to various centrifuge stresses. Rapid onset acceleration produced greater decreases in skin resistance than gradual onset acceleration or rapid onset acceleration of subjects protected by anti-G suits.

Aircrew Comfort and Survival. *The Aeroplane*, Mar. 20, 1959, pp. 348–350. Discussion of comfort and safety requirements in the development of survival equipment.

Studies in the Chemistry of Stress. IV—Further Chromatographic Studies of the Excretion of Aromatic Compounds in Stress. P. Smith. *Gt. Brit., FPRC 1050*, June, 1958. 6 pp. 10 refs.

Accommodative Fatigue in the Aging Radar Observer. J. A. Hirsch. *USAF WADC TR 58-24 [AD 142297]*, Apr., 1958. 11 pp. 34 refs. Study of ocular fatigue in radar observers to determine if an ophthalmic appliance for the observer or an optical magnifier for the scope presentation would aid in the alleviation of this problem.

Physiologic Response to Subgravity. I—Mechanics of Nourishment and Deglutition of Solids and Liquids. J. E. Ward, W. R. Hawkins, and Herbert Stallings. *J. Av. Med.*, Mar., 1959, pp. 151–154.

On the Behavior of the Human ERG Over a Wide Range of Luminances. Lucia Ronchi. *(Fond. Giorgio Ronchi, Atti*, Sept.-Oct., 1958, pp. 449–461.) *Inst. Naz. Ottica, No. 843 (AFOSR TN 59-119) [AD 210424]*, 1958. 13 pp. 26 refs. Reprint.

The Validity of Motokawa's Technique for Investigating Retinal Function. C. I. Howarth and M. Treisman. *Gt. Brit., FPRC 1035*, June, 1958. 3 pp. 13 refs.

On the Fusion Conditions of a Colored Flickering Field. Marcella Bittini. *(Fond. Giorgio Ronchi, Atti*, Sept.-Oct., 1958, pp. 442–448.) *Inst. Naz. Ottica, No. 842 (AFOSR TN 59-121) [AD 210426]*, 1958. 7 pp. 10 refs. Reprint.

The Human Eye as a Detector of Threshold Signals. C. I. Howarth. *Gt. Brit., FPRC 1028*, Apr., 1958. 4 pp. 12 refs.

Basic Research in the Field of Vision. *Inst. Naz. Ottica Final Rep. (AFOSR TR 59-14) [AD 210473]*, Nov., 1958. 28 pp. 14 refs.

Responses of the Auditory Cortex to Repetitive Acoustic Stimuli. M. H. Goldstein, Jr., N. Y-S. Kiang, and R. M. Brown. *ASA J.*, Mar., 1959, pp. 356–364. 39 refs. USAF-Army-Navy-supported study.

The Effect of Warning Interval on Thresholds. C. I. Howarth and M. Treisman. *Gt. Brit., FPRC 1034*, June, 1958. 9 pp. 10 refs.

Thermoelectric Measurement of Cerebral Blood Flow. R. R. Sonnenschein. *USAF WADC TR 58-60 [AD 151033]*, Mar., 1958. 12 pp. 18 refs.

Effect of Unilateral Chronic Lesions of the Midbrain on the Electrocortical Activity of the Cat. J. P. Cordeau and Mauro Mancia. *(Arch. Ital. Biol.*, 1958, pp. 374–379.) *USAF OSR TN 59-117 [AD 210422]*, 1958. 26 pp. 30 refs. Reprint.

May Psychological Factors Influence the Electroretinographic Response? Marcella Bittini and Lucia Ronchi. *(Fond. Giorgio Ronchi, Atti*, Sept.-Oct., 1958, pp. 417, 418.) *Inst. Naz. Ottica, No. 841 (AFOSR TN 59-120) [AD 210-425]*, 1958. 2 pp. Reprint.

Effect of Stress on Lower Neuron Activity. R. Margaria, T. Gualtierotti, and D. Spinelli. *(Exp. Med. & Surgery*, June-Sept., 1958, pp. 166–176.) *USAF OSR TN 58-537 [AD 158353]*, 1958. 11 pp. 12 refs.

The Experimental Approach to Pain. A. E. McKenna. *(J. Appl. Physiol.*, Nov., 1958, pp. 449–456.) *USAF OSR TN 59-122 [AD 210427]*, 1958. 8 pp. 21 refs. Reprint.

Physical Working Capacity of Swedish Air Force Pilots. Wilhelm von Döbeln, Carl-Gunnar Engström, and Gunnar Ström. *(2nd Europ. Congr. Av. Med., Stockholm, Sept. 18, 1957.) J. Av. Med.*, Mar., 1959, pp. 162–166. 14 refs. Description of the results of the physical working capacity examination, with special reference to the method used and the effects of age and military occupation.

Development of Conductive Cloth Plantar Electrode for Use in Measuring Skin Resistance. N. K. Morrison. *USAF WADC TN 58-284 [AD 204425]*, Oct., 1958. 11 pp.

Maximal Inspiratory and Expiratory Stroke Volumes in Human Subjects as Related to Body Posture. F. G. Hall and John Salzano. *J. Av. Med.*, Mar., 1959, pp. 167–172.

Factors Affecting the Pulmonary Dead Space as Determined by Single Breath Analysis. R. H. Shepard, E. J. M. Campbell, and H. B. Martin. *USAF SAM Rep. 58-138*, Dec., 1958. 5 pp.

Changes in Cerebral Oxygen Availability from Induced Hypoxia in Cats. N. B. Furlong, Jr., and M. J. Schwarz. *USAF WADC TR 58-322 [AD 203904]*, Oct., 1958. 12 pp.

Human Engineering

Dynamic Response of Human Operators. D. T. McRuer and E. S. Krendel. *USAF WADC TR 56-524 [AD 110693]*, Oct., 1957. 248 pp. 95 refs. Investigation to find a suitable mathe-

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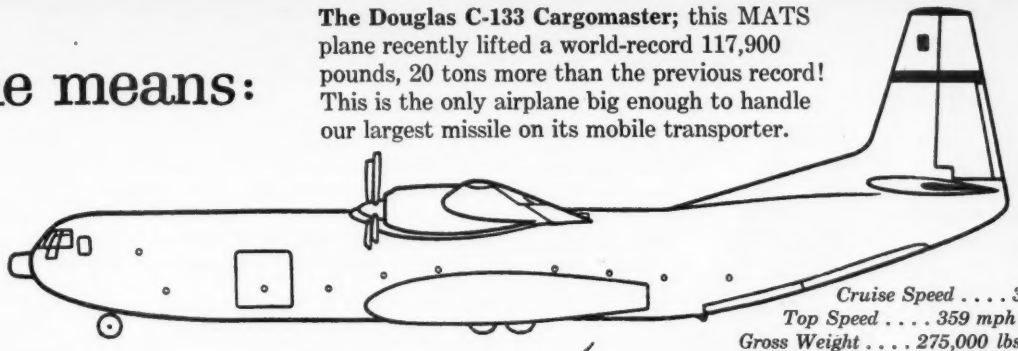

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matical description of human operator's dynamic response. Primary concern is with operations in which continuous closed-loop control is exerted in a visual input–manual output tracking situation subjected to excitation by random appearing forcing functions.

An Investigation of the Performance of the Human Monitor. Daniel Howland. *USAF WADC TN 57-431 [AD 142259]*, July, 1958. 15 pp. 10 refs. Study of the behavior of the human being acting as a monitor, made in terms of the changes that may be expected in his performance over long periods of time, the decisions he makes, and the basis for these decisions.

Handling Qualities and Pilot Dynamics. Ch. B. Westbrook and D. T. McRuer. *Aero/Space Engrg.*, May, 1959, pp. 26–32. 11 refs. Review of several examples of the origin and establishment of current requirements together with research techniques and programs illustrating some of the processes involved in the delineation and handling quality requirements in the Air Force. The pilot opinion and human-servo approaches are discussed, and recent efforts directed toward the correlation of these approaches are reviewed.

Human Factors Considerations in Helicopter Design. W. G. Matheny. *IAS 27th Annual Meeting, New York, Jan. 26–29, 1959, Rep. 59-83.* 10 pp. Members, $0.50; nonmembers, $1.00. Discussion of two problems in equipment design: stabilizing and displaying information.

Functional Mock-Ups for Aircrew. M. G. Whillans. *(CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 852.) Can. Aero. J.*, Mar., 1959, pp. 110–113. 10 refs.

Chemistry

Vliianie Ionov Chetyrekhvalentnogo Titana na Elektrokhimicheskie Svoistva i Korrozionnoe Povedenie Titana. V. V. Andreeva and V. I. Kazarin. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 1,048–1,051. In Russian. Study of the effect of quadrivalent titanium ions on the electrochemical properties and corrosive behavior of titanium.

The Crystal Structure of $SeOCl_2.2C_5H_5N$. Günther Nahringbauer and Ingvar Lindqvist. *Uppsala U. Inst. Chem. TN 2 (AFOSR TN 59-64) [AD 209608]*, Dec. 20, 1958. 17 pp. 19 refs.

The Crystal Structure of $Ni_{12}P_5$. Stig Rundqvist and Egon Larsson. *Uppsala U. Inst. Chem. TN 4 (AFOSR TN 59-35) [AD 209207]*, Nov. 22, 1958. 12 pp. 11 refs.

Epurateur d'Hydrogène à Vapeur de Magnésium. A. Hivert. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 54, 55. In French. Description of a device for purifying compressed hydrogen by means of magnesium vapor.

Study of Iridium Compounds. Lamberto Malatesta. *Milan U. TN 1 (AFOSR TN 59-123) [AD 210428]*, Oct. 31, 1958. 35 pp.

Addition Compounds of Antimony Chlorides with Sulfoxides and Sulfones. Ingvar Lindqvist. *Uppsala U. Inst. Chem. TN 1 (AFOSR TN 59-116) [AD 210421]*, Oct. 20, 1958. 11 pp.

Design and Operating Criteria for Fluorine Disposal by Reaction with Charcoal. H. W. Schmidt. *U.S., NASA Memo. 1-27-59E*, Feb., 1959. 18 pp.

Quantitative Organic Analysis. XIII—A Rapid Method for C and H Micro-Determination in Organic Substances. M. Vechera, D. Shnobl, and L. Synek. *(Mikrochim. Acta*, No. 1, 1958, pp. 9–27.) *Gt. Brit., RAE Lib. Transl. 752*, Oct., 1958. 16 pp. 30 refs.

Kinetics and Mechanism of the Dehydrogenation of Iso-Propyl Alcohol on Cr_2O_3. J. F. García de la Banda and G. Kremenić Orlandini. *Inst. Quim. Fis. TN 1 (AFOSR TN 59-36) [AD 209208]*, Nov., 1958. 51 pp. 49 refs.

O Prirode Kislotnosti Aliumosilikatnykh Katalizatorov Krekinga. K. V. Topchieva and I. F. Moskovskaia. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 891–894. 16 refs. In Russian. Evaluation of methods for studying the nature of acidity of silica-alumina cracking catalysts.

Computers

Realizatsiia Skhem Diskretnykh Korrektorov. M. A. Gavrilov, V. M. Ostianu, V. N. Rodin, and B. L. Timofeev. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 1,025–1,028. In Russian. Study of the specific properties of discrete corrector schemes and realization of a type of corrector for contact relays, crystal elements, and hysteresis elements.

Design Guide Analog Computing Mechanisms. G. W. Michalec. *Mach. Des.*, Mar., 19, 1959, pp. 157–179. 19 refs. Presentation of a comprehensive design guide to special and general-purpose mechanisms for performing mathematical operations in all-mechanical or electromechanical computers.

Sampling Discriminators for Data Reduction. P. S. Bengston. *Electronics*, Mar. 27, 1959, pp. 70–72. Presentation of a new method for discrimination of FM signals from magnetic tape using the outputs of two types of discriminators. The reference and data samplers are described.

A System for Automatic Processing of Fatigue Data. A. J. Belfour and W. S. Hyler. *USAF WADC TR 58-461 [AD 207792]*, Jan., 1959. 189 pp. 58 refs.

Automatic Error Correction in Teleprinter Transmission Systems. F. Ott. *(Bul. Assoc. Suisse Elec.*, No. 49, 1958, pp. 468–474.) *Gt. Brit., RAE Lib. Transl. 791*, Nov., 1958. 9 pp.

Dynamic Systems Synthesizer. E. C. Hutter, J. Lehmann, J. E. Lindsay, C. C. Shumard, S. Sternberg, J. A. Strother, and M. L. Wadlin. *USAF WADC TR 56-22 [AD 110687]*, Nov., 1956. 213 pp. Study of the specifications, requirements, and a programing system for an analog computer facility to simulate modern guided missile systems.

Space-Charge Simulation in an Electrolytic Tank. T. Van Duzer and G. R. Brewer. *J. Appl. Phys.*, Mar., 1959, pp. 291–301. 14 refs. Description of a method for the simulation of space charge in an electrolytic tank by the introduction of currents into the electrolyte by means of sources projecting through the tank floor.

Control Theory

The Describing Function Technique. J. C. West. *Soc. Instr. Tech. Trans.*, Mar., 1959, pp. 1–8; Discussion, pp. 8, 9. 15 refs. Explanation of the use of the newly developed analytical technique in control engineering.

Servo Repeater Distributes Attitude and Heading Data to Aircraft Control Systems. J. S. Collins. *Can. Aircraft Ind.*, Feb., 1959, pp. 35–37, 40.

Magnetic Clutches Add Muscle to Electronic Servos. Dunstan Graham. *Space/Aeronautics*, Apr., 1959, pp. 138–141. Description of dry-powder magnetic clutch servos. Fundamentals of magnetic clutch design, closed-loop operation, and dynamic response are discussed.

Spectral Methods for the Study of Servo Circuits Defined by Linear Differential Equations with Stochastic Coefficients. Mauritz Sundström. *KTH Aero. TN 48*, Sept., 1958. 11 pp.

Documentation

The Storage and Retrieval of Nonnumerical Data in Large and Complex Documentation Systems. Allen Kent and J. W. Perry. *Western Reserve U. Cen. Doc. & Commun. Res. TN 6 (AFOSR TN 59-82) [AD 210142]*, Feb. 24, 1959. 25 pp.

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Education & Training

Intelligibility of Known and Unknown Message Sets. Irwin Pollack, Herbert Rubenstein, and Louis Decker. *(USAF CRC TR 58-1 [AD 152651]*, 1958.) *ASA J.*, Mar., 1959, pp. 273–279. 14 refs.

Use of Flight Simulators for Pilot-Control Problems. G. A. Rathert, Jr., B. Y. Creer, and J. G. Douvillier, Jr. *U.S., NASA Memo. 3-6-59A*, Feb., 1959. 14 pp. Comparison of actual flight results and results obtained with fixed and moving flight simulators in order to study the importance of providing motion stimuli in a simulator to permit realistic operation by the pilot.

Electronics

Izluchenie Tochechnogo Zariada, Ravnomerno Dvizhushchegosia po Osi Kruglogo Otverstviia v Beskonechnoi Ideal'no Provodiashchei Ploskosti. V. Bobrinev and V. Braginskii. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 634–636. In Russian. Study covering the radiation from a point charge moving uniformly along the axis of a circular hole in an infinite, ideally conducting plane.

Amplifiers

Basic Research in Microwave Electronics. J. R. Singer, C. Süsskind, and J. R. Whinnery. *U. Calif. Inst. Eng. Res., Ser. 60/1215 (AFOSR TN 58-989) [AD 205909]*, Oct. 31, 1958. 24 pp. 19 refs. Description of noise measurements on a backward-wave amplifier with movable gun-circuit spacing in order to study space-charge waves in their coupling to the backward-wave circuit. A solid-state maser using adiabatic fast passage in irradiated magnesium oxide is described.

The Physical Principles of a Negative-Mass Amplifier. Herbert Krömer. *IRE Proc.*, Mar., 1959, pp. 397–406. 15 refs.

Increasing the Input Impedance in Transistor Amplifiers. A. D. Evans. *Electronic Ind.*, Mar., 1959, pp. 84, 85. Discussion on the use of negative feedback to increase the input impedance and to make the voltage gain more independent of transistor parameters. The description of a transistor amplifier includes the simplified as well as the complete circuit.

Simple General Analysis of Amplifier Devices with Emitter, Control, and Collector Functions. E. O. Johnson and A. Rose. *IRE Proc.*, Mar., 1959, pp. 407–418. 19 refs.

Antennas, Radomes

Determination of the Radiation Incident on a Circular Diaphragm from a Surface Emitting According to Lambert's Law. M. M. Agrest. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,244–1,248. Translation.

When You Can Use Microwave Lenses. R. W. Martin and W. M. Yarnell. *Space/Aeronautics*, Apr., 1959, pp. 142–145. 10 refs. Review of the advantages and applications of the various types of microwave radar lens antennas (constrained and unconstrained media with constant or variable refractive index). Design principles of "ray tracings" are explained, and problems of zoning and surface matching are analyzed.

Circuits & Components

Transistor Equivalent Circuit. D. A. Green. *Electronic & Radio Engr.*, Mar., 1959, pp. 108–114. Presentation of a new equivalent circuit for a transistor, valid at all frequencies where the device gives useful gain. Performance calculations are made and formulas are given for the hybrid parameters, power gain, and the conditions necessary for optimum gain in the common-emitter connection. A comparison of measurements is made.

Saturable-Transformer Switches; Application to Magnetic-Drum Head Selection. B. D. Simmons. *Electronic & Radio Engr.*, Mar., 1959, pp. 82–90. Design and construction of a saturable transformer used in a selection system, in which a large number of magnetic-drum heads share common read and write amplifiers. Circuits are described for the operation of a matrix selection system and, in particular, a simple arrangement using transistors which switches heads in a few tens of microsec.

Communications

Evaluation of Collins SSB KWT-6/5 Transceiver. Bernard Cooper. *USAF RADC TR 58-154 [AD 205918]*, Dec., 1958. 16 pp. Description of test methods and presentation of results indicating a deficiency in the AGC system inherent in current SSB receiving equipment.

RF Loss in Rocket Flame Easy to Figure. R. J. Schmelzer. *Space/Aeronautics*, Apr., 1959, pp. 171, 172, 174, 176, 178. Review of problems of radio propagation through rocket exhaust flames. Effect of flame expansion in low ambient pressure of high altitudes is described. Total attenuations through a typical flame are obtained by simple analysis.

System Designing—Communicating in Space. II. L. P. Yeh. *Electronic Ind.*, Mar., 1959, pp. 94–99. 16 refs. Discussion of space communication from the overall and performance points of view, and analysis of known techniques and experimental data.

Satellite Doppler Measurements and the Ionosphere. J. A. Thomas and F. H. Hibberd. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 376–379. Analysis of the effect of the ionosphere on the simultaneous Doppler frequency shifts of the 20 and 40 mc./sec. signals from Sputnik I. The method of analysis is outlined and preliminary results are presented.

Cooling

Techniques for the Cooling Design of Airborne Electronic Equipment; Design Methods and Charts for Heat Exchange Devices Applicable to Indirect Cooling of Electronic Assemblies. Walter Robinson. *USAF WADC TR 57-331, Suppl. I [AD 150969]*, Dec., 1957. 152 pp.

Dielectrics

Selection Guide for Silicone Dielectrics. C. G. Currin. *Electronics*, Apr. 10, 1959, pp. 64, 65.

Electronic Tubes

Electron Tubes for Critical Environments. W. H. Kohl and Philip Rice. *USAF WADC TR 57-434 [AD 151158]*, Mar., 1958. 219 pp. 318 refs. Review of the present state of development of electron tubes for operation at temperatures up to 500°C. at high levels of shock and vibration and in nuclear radiation.

Thermionic Diode as a Heat-to-Electrical-Power Transducer. W. B. Nottingham. *J. Appl. Phys.*, Mar., 1959, pp. 413–417. USAF-Army-Navy-supported analysis showing a high-vacuum thermionic diode is capable of converting heat to electric power. For this purpose, a low work-function collector, a small spacing, and sufficient temperature difference between the emitter and the collector are necessary.

Multicolor Storage Tube. L. L. Vant-Hull and Ch. D. Beintema. *USAF WADC TR 57-400 [AD 151113]*, Mar., 1958. 59 pp. 14 refs. Development of multicolor storage tubes for applications involving low frame rates, such as radar-computer systems. A perforated shadow-mask is placed between the three writing guns and the storage surface. The mask allows electrons from each writing gun to strike discrete storage areas, each containing a single aperture in register with a color dot on the view plate.

Magnetic Devices

The Effect of Temperature on the A-C Magnetic Properties of Nickel-Iron Alloys. J. J. Clark and J. F. Fritz. *USAF WADC TN 58-277 [AD 203397]*, Aug., 1958. 40 pp.

Some Properties of Quenched Magnesium Ferrites. D. J. Epstein and B. Frackiewicz. *(Conf. Magnetism & Magnetic Materials, Wash., Nov. 18–21, 1957.) MIT LIR TR 134*, Jan., 1959. 9 pp. USAF-Army-Navy-supported research.

On Determining Magnetic and Electric Fields Near Thin Films and Shells. L. A. Tseitlin. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,231–1,233. Translation.

Temperature-Dependent Lag in Polycrystalline Yttrium-Iron Garnet. D. J. Epstein and B. Frackiewicz. *(Conf. Magnetism & Magnetic Materials, Phila., Nov. 17–20, 1958.) MIT LIR TR 135*, Jan., 1959. 10 pp. 11 refs. USAF-Army-Navy-supported research.

Measurement & Testing

Photographic Method for Pulse Amplitude Analysis. P. J. Kennedy and P. J. Dean. *J. Sci. Instr.*, Mar., 1959, pp. 126–129. Description of a method by which pulse height spectra may be obtained by photographing a cathode-ray oscilloscope display.

Piezoelectricity

Calculations for a Piston-Type Piezoelectric Radiator When Internal Losses Are Neglected. A. A. Anan'eva. *Sov. Phys. - Acous.*, July-Sept., 1958, pp. 227–236. 10 refs. Translation.

Piezoelectric Relations and the Radial Deformation of a Polarized Spherical Shell. R. A. Toupin. *ASA J.*, Mar., 1959, pp. 315–318. Derivation of the piezoelectric relations and equations of equilibrium for a shell permanently polarized in the radial direction. The solution for the radial displacement corresponding to uniform pressures on the inner and outer surfaces of the shell and a given voltage difference between the surfaces is obtained.

A Low-Impedance Crystal Transducer. Wilson Bradley, Jr. *(ISA 13th Annual Conf., Phila., Sept. 17, 1958.) ISA J.*, Mar., 1959, pp. 55–57. Application of two methods for obtaining the same frequency response with low impedance loads which permits operation into impedances as low as 1 to 10 megohms.

Field-Strength Effects in Cadmium Sulfide Single Crystals. H. Gildea. *MIT LIR TR 133*, Dec., 1958. 16 pp. 11 refs. USAF-Army-Navy-AEC-supported research.

Power Supplies

High-Power Transistor D.C. Converters. T. R. Pye. *Electronic & Radio Engr.*, Mar., 1959, pp. 96–105. Review of transistor circuits for d.c. conversion. The transformer-coupled push-pull circuit is examined, and examples are given of designs using both silicon and germanium power transistors.

Silicon Power Rectifiers. R. F. Edwards. *Electronics*, Apr. 10, 1959, p. 71. Presentation of the current rating and peak inverse voltage of military standard silicon power diodes.

Missile Power Supplies. J. A. Herbst and Victor Krummenacher. *Missile Des. & Devel.*, Mar., 1959, pp. 14–19. Discussion of various power supply requirements including size, ambient temperature, protection, packaging, and maintenance.

Power for Satellites. J. H. Huth. *Western Av.*, Mar., 1959, pp. 44, 45. Comparison of solar batteries, electrochemical batteries, and nuclear power as to weight, life, and power output.

New Power Sources for Space-Age Electronics. David Linden and A. F. Daniel. *Electronics*, Mar. 20, 1959, pp. 43–47. Discussion on the development of chemical, nuclear, and solar energy as the three prime sources for electrical power in space. Various energy conversion means are considered.

Solar Cell R & D Shooting for 16-22 per cent Efficiencies. J. I. Davis. *Space/Aeronautics*, Apr., 1959, pp. 44–46. Discussion of design considerations for solar cell systems with emphasis on electrochemical and thermal factors. Graphs of silicon solar cell characteristics and configurations of oriented systems are presented.

Power Stations on the Moon. P. A. Castruccio. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 42, 43. Discussion covering such factors as the use of the sun for photoelectric power generation and a proposal for a moon power station.

Radar

Precision Generator for Radar Range Calibration. Donald Broderick, Dexter Hartke, and Marvin Willrodt. *Electronics*, Apr. 3, 1959, pp. 58–60. Description of an instrument that produces two delayed pulses for establishing accurate time intervals from 1 to 10,000 μsec. Delays are adjustable in 1-μsec. increments with continuous interpolation between steps.

A Radar Mapping Display Simulation and Performance Recording Device. J. R. Biagioni, R. K. McKelvey, and J. F. Mousted. *USAF WADC TN 58-210 [AD 203396]*, Sept., 1958. 14 pp.

Reliability

Predicting the Reliability of Complex Electronic Equipment. A. G. Field. *Soc. Instr. Tech. Trans.*, Mar., 1959, pp. 18–23. Calculation of the reliability on the basis of a constant failure rate, and discussion of the effects of ambient conditions on failure rate.

Semiconductors

K Voprosu o Poluprovodnikovykh Svoistvakh Zhelezo-Mednykh Katalizatorov Sinteza i Aktiviruiushchem Deistvii Shchelochnogo Promotora. I. B. Rapoport and V. N. Kulakov. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 887–890. 11 refs. In Russian. Determination of semiconducting properties of iron-copper catalysts and the activating effect of alkaline promoters in synthesis.

Okislenie Dvukhvalentnogo Vanadiia na Germanievom Anode. Iu. V. Pleskov and B. N. Kabanov. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 884–886. In Russian. Study of the oxidation of bivalent vanadium on a germanium anode.

The Tecnetron. S. Teszner. *(CNET*, France, 1958.) *Gt. Brit., RAE Lib. Transl. 777*, Oct., 1958. 11 pp. Discussion of the physical theory of a germanium-indium semiconductor amplifier/oscillator.

Effekt Faradeia na Eksitonakh Motta. A. G. Samoilovich and L. L. Korenblit. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 828–831. In Russian. Study of the Faraday effect for Mott's excitons of not too large radius ($d < 10^{-5}$ cm.).

Telemetry

Transistors Improve Telemeter Transmitter. Donald Enemark. *Electronics*, Mar. 13, 1959, pp. 136, 137. Description of new transmitter and modulator with lower power requirements than vacuum tube types. As a result, battery weight is reduced for balloon-borne radiation detector gear.

La Télémesure O.N.E.R.A. H. Le Boiteux and G. Moussette. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 3–7. In French. Descrip-

tion of the telemetering system developed by ONERA, including the operating characteristics, as well as various test requirements and techniques of application.

Transmission Lines

Scattering of Sound Waves in Irregular Waveguides. A. D. Lapin. *Sov. Phys. - Acous.*, July-Sept., 1958, pp. 272–279. Translation. Presentation of a modification of Rytov's method for calculating the scattering in singular wave guides for the case when the scattered field is large in comparison with the incident field.

Motion of a Charged Particle in a Rectangular Waveguide Filled with an Anisotropic Dielectric. L. S. Bogdankevich. *Sov. Phys. - Tech. Phys.*, July, 1958, pp. 1,392–1,395. Translation.

Generation of Surface Waves at the Open End of a Plane Waveguide. V. I. Talanov. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,185–1,195. Translation.

Traveling-Wave Couplers for Longitudinal Beam-Type Amplifiers. R. W. Gould. *IRE Proc.*, Mar., 1959, pp. 419–426. Development of the theory of longitudinal-beam traveling wave couplers and application to the design of couplers for parametric amplifiers. The properties of fast space-charge wave couplers are described.

Asimptotika Sobstvennykh Funktsii Uravneniia $\Delta u + k^2u = 0$ s Kraevymi Usloviiami na Ekvidistantnykh Krivykh i Rasseianie Elektromagnitnykh Voln v Volnovode. V. P. Maslov. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 631–633. In Russian. Determination of the asymptotic behavior of the characteristic functions of equation $\Delta u + k^2u = 0$ with boundary conditions along equidistant curves and the scattering of electromagnetic waves in a wave guide.

Propagation of Electromagnetic Waves in Circular Waveguides with Periodic Slits. N.N. Smirnov. *Sov. Phys. - Tech. Phys.*, July, 1958, pp. 1,383–1,391. Translation.

On the Theory of Concave Waveguides. Iu. S. Saiasov and Iu. V. Sinitsyna. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,202–1,208. Translation. Analysis of propagation of TE-type waves in a wave guide with a cross section formed by the intersection of an ellipse and a hyperbola with common foci when the separation between vertices of the hyperbola is small. Equations are found for the membrane function along with the corresponding eigenvalues.

Radiation and Energy Loss of an Electron in an Infinitely Long Wave-Guide Filled with a Linear Medium. H. Motz and M. Nakamura. *Oxford U. Eng. Lab. TN 2 (AFOSR TN 59-43) [AD 209215]*, Oct., 1958. 54 pp. 11 refs.

Wave Theory

Characteristics of a Peculiar Back-Scatter Echo Observed at a Frequency of 21.6 mc. p.s. B. Dueño. *Puerto Rico U. FEE RR 1*, 1958. 24 pp. AFOSR-supported study.

Interference from the Ionosphere. M. L. Shapiro. *Electronic Ind.*, Mar., 1959, pp. 76–78. Determination of the possibilities of subjection of directional antennas pointing skyward to ionospheric reflection interference.

Millimeter Waves: Future Depends on Component Development. James Holahan. *Space/Aeronautics*, Apr., 1959, pp. 134–137. Review of millimeter wave applications and development trends. High- and low-power signal sources and new approaches to millimeter generation are discussed. Recently declassified high definition millimeter radar design characteristics are presented.

The Interaction Between an Obliquely Incident Plane Electromagnetic Wave and an Electron Beam. III. Hans Wilhelmsson. *Chalmers Tek. Högskolas Handlingar, No. 206*, 1958. 17 pp.

On the Properties of the Electron Beam in the Presence of an Axial Magnetic Field of Arbitrary Strength. Hans Wilhelmsson. *Chalmers Tek. Högskolas Handlingar, No. 205*, 1958. 31 pp.

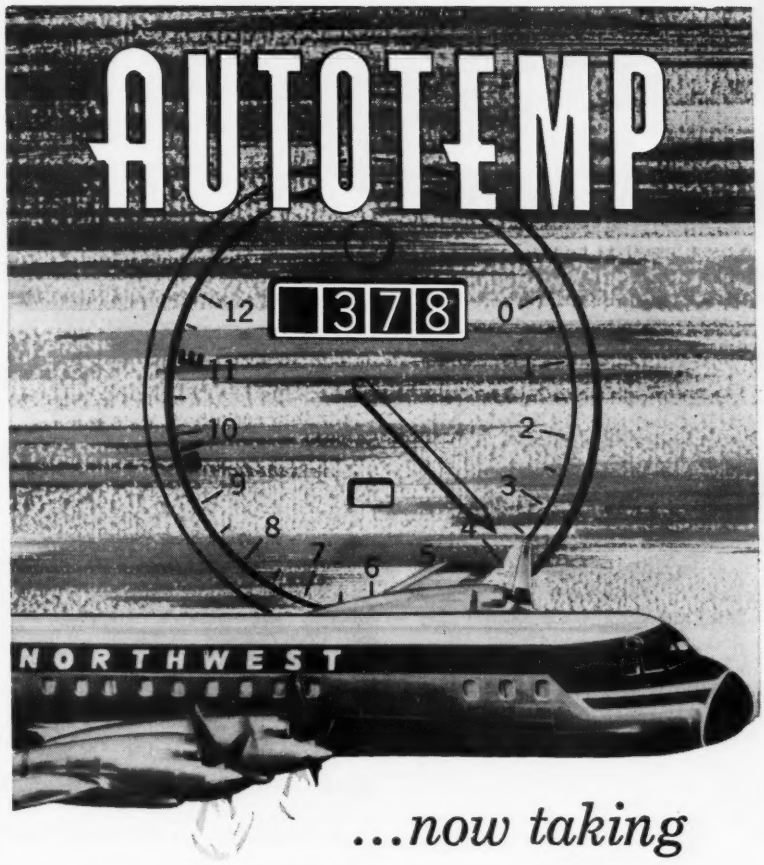
High-Frequency Breakdown in Air at High Altitudes. A. D. MacDonald. *IRE Proc.*, Mar., 1959, pp. 436–441. Analysis of microwave breakdown near antennas in order to find limitations on transmission conditions. The fundamental processes are described.

Equipment

Electric

L'Equipement Electrique du Bristol "Britannia." III—Batteries; Alimentation au Sol; Circuits Secondaires; Régulations et Alimentations Diverses. H. Lanoy. *Docaéro*, Jan., 1959, pp. 49–60. In French. Further description of the electric equipment for the Bristol Britannia covering batteries, ground power supplies, secondary circuits, and applications of electric energy to various systems of the aircraft.

Caractéristiques d'Emploi Comparées des Divers Types d'Accumulateurs Electriques de Bord. A. Sageau, J. Couzy, and R. Veyrac. *Docaéro*, Jan., 1959, pp. 33–48. 11 refs. In French. Comparative evaluation of the characteristics of



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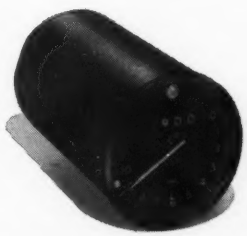

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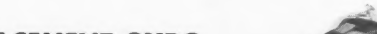

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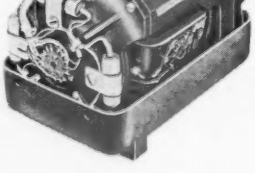

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Hydraulic & Pneumatic

Performance Depends Upon Design for Gain in Hydraulic-Control Systems. J. H. Kogen and R. G. Reip. *Mach. Des.*, Apr. 2, 1959, pp. 126–131. Description of some ways of achieving gain adjustment in hydraulic systems.

Fuels & Lubricants

Bacterial Activity in JP-4 Fuel. Sam Bakanauskas. *USAF WADC TR 58-32 [AD 151034]*, Mar., 1958. 15 pp. Study of sludge samples from tanks used to store JP-4 fuel, showing that the sludge is caused by bacteria. Recommendations are made for additives to eliminate this condition.

Flow Properties of ATK at Low Temperatures. S. C. Dodson and A. G. C. Fairman. *Air BP*, No. 10, 1959, pp. 14–19. Description of tests to measure the low temperature performance of a selection of kerosene-base fuels under a variety of operating conditions, in a rig representative of an aircraft fuel system, and determination of a laboratory test reproducing adequately the rig results.

Research on the Flammability Characteristics of Aircraft Hydraulic Fluids. Appendix I—**Tables of Minimum Spontaneous Ignition Temperatures.** M. G. Zabetakis, A. C. Imhof, and F. W. Lang. *USAF WADC TR 57-151, Suppl. 1 [AD 155510]*, May, 1958. 29 pp. Presentation of the results of spontaneous ignition temperature tests conducted on JP-4 and seven hydraulic fluids. The flash and fire points of these fluids were also determined.

L'Amélioration de la Sécurité des Avions par le Perfectionnement des Fluides de Transmission. Ch. Horny. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 21–30. In French. Survey of various types of hydraulic fluids used in aircraft and results of an investigation for improving the safety factor by suitable choice of their chemical composition.

Laboratory Evaluation of Silane Fluids as Potential Base Stocks for Hydraulic Fluids and Lubricants. H. W. Adams and George Baum. *USAF WADC TR 57-168 [AD 142141]*, Mar., 1958. 27 pp. Presentation of physical and chemical properties of alkyl and alkyl-aryl silanes indicating good thermal stability up to 650°F., good lubricity, and marginal oxidative stability at 500°F.

Hydrodynamic Lubrication and Its Implication for Journal Bearing Design. F. T. Barwell. *Appl. Mech. Rev.*, Mar., 1959, pp. 149–153. 93 refs.

Lubricating Properties of Lead-Monoxide-Base Coatings of Various Compositions at Temperatures to 1250°F. H. E. Sliney. *U.S., NASA Memo. 3-2-59E*, Feb., 1959. 22 pp. 11 refs. Study of a number of ceramic coatings to determine their relative merits as dry-film lubricants.

On the Theory of Sliding Contacts. F. Schroeter. (*ETZ-A*, No. 79, 1958, pp. 498–501.) *Gt. Brit., RAE Lib. Transl. 794*, Dec., 1958. 10 pp.

Lubrication of Titanium. II. Nicholas Fatica. *USAF WADC TR 57-61, Pt. II [AD 155564]*, May, 1958. 78 pp. Investigation of the frictional properties of modified titanium coatings and comparison of the wear resistance of the best surface treatments in the presence of various lubricants using the Shell Four-Ball Wear Tester and the Falex Tester.

Compression Sensitivity of Monopropellants. G. A. Mead. *ARS J.*, Mar., 1959, pp. 192–198. Development of a method for evaluating the sensitivity of liquid monopropellants to initiation of decomposition in the presence of rapidly compressed gas bubbles. A theoretical analysis and experimental data for several monofuels are given, and the process of data reduction is described.

Isothermal Compressibility of Liquid Oxygen and RP-1. G. T. Y. Chao. *ARS J.*, Mar., 1959, pp. 199–203. 14 refs. Presentation of methods for calculating the isothermal compressibility, including evaluation of the quantitative relation of densities for the propellants under pressurized conditions.

Ice Formation & Prevention

Note on an Apparatus for the Study of the Impact Between a Liquid Drop and a Surface Moving at Supersonic Speed. D. C. Jenkins and J. D. Booker. *Gt. Brit., RAE TN Mech. Eng. 267*, July, 1958. 13 pp.

Instruments

Analyseur en Vol de Gaz de Combustion. J. Fructus. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 19, 20. In French. Description of an analyzer used to measure in flight the combustion efficiency of jet power plants.

Ob Odnoi Lineinoi Granichnoi Zadache Obobshchennoi Gidrodinamiki—K Teorii Ul'trazvukovogo Interferometra. I. I. Ol'khovskii. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 821–824. In Russian. Derivation of a solution for the linear boundary problem of generalized hydrodynamics defined as the acoustic aspect of the supersonic interferometer theory. The calculation is based on Boltzmann's kinetic equation for monatomic gases.

Accelerometers

Acoustical Damping for Linear Accelerometers. C. K. Stedman. *ASA J.*, Mar., 1959, pp. 333–337.

Flight Instruments

Precision Pressure Altimeters for Air Traffic Separation and Terrain Clearance. F. C. Melchior. *IAS 27th Annual Meeting, New York, Jan. 26–29, 1959, Rep. 59-84.* 15 pp. Members, $0.50; nonmembers, $1.00. Discussion of the operating principles of an altimeter which indicates absolute pressure altitude without constant resettings or checking of published field elevations.

Aircraft Aerodynamic Height and Speed Quantities; Their Characteristics and Co-Relation. A. G. Bone. *Gt. Brit., RAE TN I.A.P. 1085*, Mar., 1958. 46 pp. Development of expressions relating pitot and static pressure with temperature. The characteristics of height and speed quantities and their correlation are presented graphically.

Flow Measuring Devices

Electron Beam Density Probe for Measurements in Rarefied Gas Flows. F. C. Hurlbut. *J. Appl. Phys.*, Mar., 1959, pp. 273–279. 14 refs. Description of an instrument to determine the density in a rarefied gas stream utilizing the attenuation of an electron beam.

Determination of Transient Pressure Flow Relationship by Momentum Measurements. E. J. Croke and Jerry Grey. *ARS J.*, Mar., 1959, pp. 213, 214. Application of a momentum-sensitive device to measure the transient flow rate through a rocket motor injector. The validity of the theoretical calculation is checked.

On Quantitative Measurement of Turbulence by Means of a Constant Resistance Hot-Wire Anemometer. Nisiki Hayasi. *Phys. Soc. Japan J.*, Mar., 1959, pp. 360–365.

Determination of Local Skin Friction by Means of Surface Total-Pressure Probes. J. A. Martin. *J. Aero/Space Sci.*, May, 1959, p. 320.

Gyroscopes

Lax Specs Cause Confusion in Rate Gyro Field. N. W. Batterman. *Space/Aeronautics*, Apr., 1959, pp. 159, 161, 162, 165, 168. Presentation of pertinent design parameters for rate gyros. Interrelationships of these parameters are shown, and performance characteristics are defined.

Panels & Dials

Spacing of On-Off Controls. I—Push Buttons. J. V. Bradley and R. A. Wallis. *USAF WADC TR 58-2 [AD 142272]*, Apr., 1958. 17 pp. 14 refs.

Shape Coding of Aircraft Instrument Zone Markings. Raymond Sabeh, W. R. Jorve, and J. M. Vanderplas. *USAF WADC TN 57-260 [AD 118343]*, Mar., 1958. 10 pp. Study to determine whether aircraft instrument zone markings could be profitably shape-coded rather than color-coded as in present USAF specifications.

Pressure Measuring Devices

External Interference Effects of Flow Through Static-Pressure Orifices of an Airspeed Head at Several Supersonic Mach Numbers and Angles of Attack. N. S. Silsby. *U.S., NASA Memo. 2-13-59L*, Mar., 1959. 14 pp.

Stress & Strain Measuring Devices

A Strain Gauge Calibrator for Temperatures up to 700°C. Appendix I—**Calibration Error Produced by a Parabolic Temperature Variation Along the Central Section of the Beam.** Appendix II—**Calibration Procedure and Some Results.** K. R. Maslen and R. W. Corbin. *Gt. Brit., RAE TN Instn. 163*, Aug., 1958. 30 pp.

Tachometers

Digital Tachometer Aids in Turbine Design. J. K. Goodwin. *Electronics*, Apr. 10, 1959, pp. 58–61. Discussion of the characteristics and operation of tachometer systems.

Temperature Measuring Devices

Temperature Measurement. *Instrumentation*, Jan.-Feb., 1959, pp. 26–29. Description of a pyrometer capable of measuring temperatures from −300°F. to over 3,000°F.

Timing Devices

Clock Source for Electronic Counters. T. F. Marker. *Electronics*, Apr. 10, 1959, p. 76. Description of the operation of a transistor oscillator used in computer equipment.

Machine Elements

Bearings

Current Status of Knowledge on Design Criteria for Bearings Used in High Temperature Aircraft Electrical Accessories. P. Lewis, S. F. Murray, and A. A. Schwartz. *USAF WADC TR 58-519 [AD 203792]*, Sept., 1958. 50 pp. 40 refs.

An Investigation Into the Causes of Ball Bearing Failures in Types P2 and P3 Engine Driven Generators. Appendix—**The Estimation of the Proportion of Rogue Assemblies.** W. R. Hinton. *Gt. Brit., RAE Rep. El. 1490*, Aug., 1958. 54 pp. 13 refs.

Fastenings

Comparative Strength Tests of Tension Bolts with UNF and BSF Threads (Revised Version of Technical Note No. Structures 212). R. F. Mousley, F. Clifton, and D. Le Brocq. *Gt. Brit., ARC CP 416* (Sept., 1958) 1959. 13 pp. BIS, New York, $0.45.

Gears & Cams

Investigation of Factors Affecting High-Temperature Gear Operation. E. E. Shipley. *Lubrication Eng.*, Mar., 1959, pp. 98–103, 119. Description of a high-temperature gear testing facility, and discussion of some of the work done to find lubricants, materials, and gear designs that will operate successfully at high temperatures.

Seals

Evaluation of High Temperature Hydraulic Seals to Temperatures of 550°F. II—Polymer Compounding and Evaluating. R. G. Larkin and F. W. Bickel. *USAF WADC TR 57-76, Pt. II [AD 150973]*, Feb., 1958. 108 pp. 60 refs.

Integrated Seals Simplify Tartar Design. Wendel Haas. *Space/Aeronautics*, Apr., 1959, pp. 89, 90, 92. Description of gland-type, mechanical, integrated seals that are used on the Tartar missile.

Materials

Special Issue: Materials and Processes. *The Aeroplane*, Feb. 27, 1959, pp. 243–262. *Partial Contents*: Structural Materials for Supersonic Aircraft, N. F. Harpur and I. L. G. Baillie. Materials for Missiles and the Space-Age, J. E. Allen. Spaceflight Materials. Structural Materials for Modern Civil Aircraft, K. Bentley. Trends and Techniques—Light Alloy for Airframes; Titanium for Aircraft; Steels and Special Alloys; Glass-Fibre Developments; Applications of Metal Honeycomb; Developments in Forging; Machining Techniques; Removing the Wrinkles; Envelope Tooling; Soldering of Aluminium.

Ceramics & Ceramals

Development of a Foamed Alumina Cement. W. F. Zimmerman. (*Am. Ceram. Soc. 60th Annual Meeting, Pittsburgh, Apr. 28, 1958.*) *Am. Ceram. Soc. Bul.*, Mar., 1959, pp. 97, 98. Presentation of the properties of a lightweight phosphate bonded alumina cement, foamed by means of the acid reaction with aluminum powder in the presence of a foam stabilizer.

Corrosion & Protective Coatings

Corrosion of Stainless-Steel Welds Formed with Carbon-Dioxide Shielding. B. E. Hopkinson and D. W. McDowell. *Welding J. Res. Suppl.*, Apr., 1959, pp. 188-s–193-s. 10 refs. Comparison of the effect on weld chemistry and corrosion resistance of stainless-steel weldments made under carbon-dioxide shielding with similar welds made under argon plus 1 per cent oxygen.

Effect of Metals on Lubricants. III. J. B. Christian. *USAF WADC TR 54-576, Pt. III [AD 155518]*, May, 1958. 23 pp.

Organic Coatings for Metal Products. R. J. Fabian. *Materials in Des. Eng.*, Mar., 1959, pp. 113–128. 17 refs. Detailed manual giving the important types of coatings, their properties, and applications.

Molybdenum Coating Stands Up at 2000 deg F. *Space/Aeronautics*, Apr., 1959, pp. 97, 98, 100. Description of nickel-chromium electrodeposited coating for molybdenum.

High Temperature

Thermal Properties of High Temperature Materials. I. B. Fieldhouse, J. C. Hedge, J. I. Lang, and T. E. Waterman. *USAF WADC TR 57-487 [AD 150954]*, Feb., 1958. 79 pp. Measurement of the thermal conductivity, specific

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ACOUSTICS, SOUND, NOISE

SHIELDING FLAP TYPE JET ENGINE NOISE SUPPRESSOR. D. J. Maglieri. ASA J., Apr., 1959, pp. 420-422. Presentation of far-field noise measurements from model tests of a shielding flap-type noise suppressor in the form of radiation patterns and frequency spectra. The tests were conducted using a cold air jet issuing from the nozzle in such a manner as to attach to and flow along the surface of a shielding flap. Whereas other proposed noise suppressors provide generally symmetrical noise radiation patterns, the present device skews the pattern in a beneficial way such that large noise reductions are obtained in the downward direction. These large noise reductions are thought to result from both the acoustic shielding of the flap and the benefits of flow attachment.

DEVELOPMENT OF AIRCRAFT STRUCTURE TO WITHSTAND ACOUSTIC LOADS. P. M. Belcher, J. D. VanDyke, Jr., and A. L. Eshleman, Jr. Aero/Space Engrg., June, 1959, pp. 24-30. Description of the development program for acoustically loaded structures of the DC-8 aircraft. The acoustic loads on the structure are determined by extrapolation of near-field noise data of engines comparable in thrust to those of the DC-8. The relationship among load, response, and fatigue for both jet and sinusoidal loading were investigated theoretically. New techniques of experimental stress analysis, using a high-intensity siren, are outlined. It is shown that the results of the siren test program, used in the design of the airframe structure, are verified by accelerated tests of production structure under jet-noise loading.

AERODYNAMICS, FLUID MECHANICS

Aerothermodynamics

INFLUENCE OF LARGE POSITIVE DIHEDRAL ON HEAT TRANSFER TO LEADING EDGES OF HIGHLY SWEPT WINGS AT VERY HIGH MACH NUMBERS. Morton Cooper and P. C. Stainback. US, NASA Memo. 3-7-59L, Apr., 1959. 18 pp. Presentation of a geometric study showing that the incorporation of large positive dihedral on highly swept wings can shift, even at moderately low angles of attack, the stagnation line heat-transfer problem from the leading edges to the axis of symmetry (ridge line). An order-of-magnitude analysis (assuming laminar flow) indicates conditions for which it may be possible to reduce the heating of the ridge line (except in the vicinity of the wing apex) to a small fraction of the leading-edge heat transfer of a flat wing at the same lift. Furthermore, conditions are indicated where dihedral reduces the leading-edge heat transfer for angles of attack less than those required to shift the stagnation line from the leading edge to the ridge line.

THE THERMAL PROTECTION OF A RE-ENTRY SATELLITE. S. M. Scala. G-E MOSD TIS R59SD336, Mar. 9, 1959. 26 pp. 14 refs. Analysis of the heat flux from a re-entry satellite for three different values (50, 100, and 200) of a ballistic parameter. Three basic types of heat alleviation schemes are then considered. These are the heat sink, the regulated mass transfer system (transpiration cooling), and the self-regulated mass transfer system (vaporization cooling). The effectiveness of the three schemes is compared in terms of the total mass of material required for each. It is found that the intrinsic mass of coolant shield required for the thermal protection is a sensitive function of the cooling scheme selected. Heat sinks are not competitive with mass transfer systems. Ablating refractories constitute a superior system when compared with transpiration cooling. The re-radiation effect for ablating materials is very important and can result in a 50% reduction in mass transfer at very high temperatures.

Boundary Layer

SIMPLIFIED ANALYSIS OF BOUNDARY-LAYER OSCILLATIONS. R. Betchov. Douglas Rep. ES-29174, Mar. 15, 1959. 84 pp. Study of the incompressible boundary layer in terms of three basic processes which are discussed separately.

These are: (1) the oscillations of a boundary layer when friction is disregarded, (2) the effects of friction at the wall, and (3) the effects of friction at the critical layer. A general equation leads to the eigenvalues. The neutral curves corresponding to five typical cases are determined for parabolic and Blasius boundary layers, boundary layers with suction and adverse pressure gradient, and two-dimensional Poiseuille flow. The nonlinear effects of the oscillation on the velocity profile are evaluated. Finally, the case of a boundary layer along an elastic wall is considered, and it is found that the wall may have a significant effect on the layer. In particular, a wall with negative damping could completely stabilize the boundary layer.

CONSIDERAŢII ASUPRA UNOR SOLUŢII DIN CAZUL STRATULUI LIMITĂ COMPRESIBIL NEPERMANENT. St. N. Săvulescu. Stud. Cerc. Mec. Aplic., No. 4, 1958, pp. 867-879. In Rumanian, with summaries in Russian and French. Establishment of conditions for the external parameters of an unsteady compressible boundary layer (velocity and temperature of the external flow, and temperature at the wall), in order to extend the applicability of the Crocco solution. Typical velocity and temperature profiles are used to study specific cases for which friction and heat-transfer formulas are derived for unit Prandtl Number. A comparison to the case of steady flow is made.

AN INVESTIGATION OF THE EFFECT OF A HIGHLY FAVORABLE PRESSURE GRADIENT ON BOUNDARY-LAYER TRANSITION AS CAUSED BY VARIOUS TYPES OF ROUGHNESSES ON A 10-FOOT-DIAMETER HEMISPHERE AT SUBSONIC SPEEDS. J. B. Peterson, Jr., and E. A. Horton. US, NASA Memo. 2-8-59L, Apr., 1959. 32 pp. 10 refs. Test results for Carborundum grains, spherical particles, and rimmed craters show that the roughness Reynolds Number for transition $R_{k,t}$ is independent of the particle size or position on the hemispherical nose and depends mainly on the height-to-width ratio of the particle. The values of $R_{k,t}$ found on the hemispherical nose compare closely with those previously found on a flat plate and on airfoils with roughness. For two-dimensional roughness, the ratio of roughness height to boundary layer displacement thickness necessary to cause transition was found to increase appreciably as the roughness was moved forward on the nose. Also included in the investigation were studies of the spread of turbulence behind a single particle of roughness and the effect of holes such as pressure orifices.

INSTATIONÄRE GRENZSCHICHTEN HINTER VERDICHTUNGSSTÖSSEN UND EXPANSIONSWELLEN. Ernst Becker. ZFW, Mar., 1959, pp. 61-72. 33 refs. In German. Presentation of a survey of a specific class of nonsteady, compressible boundary layers occuring when compression shocks or expansion waves move along solid plane walls (shock tube, wind tunnel). By using simplifying assumptions, the boundary-layer equations for laminar flow are given and their solutions for various specials cases (discontinuous wave, continuous expansion wave) are discussed. The results obtained for turbulent flow through the momentum method are summarized and experimental results are presented.

CALCUL PRATIQUE DE LA COUCHE LIMITE TURBULENTE COMPRESSIBLE: PRINCIPE ET APPLICATIONS. R. Michel. France, ONERA NT 49, 1959. 33 pp. In French. Development of an approximate method of calculation used to determine the main dynamic characteristics of a turbulent boundary layer with given pressure gradients in compressible flow. The calculation is based on von Kármán's integral momentum equation. A simple formula is derived for the direct integration of the boundary-layer momentum thickness, and a comparison is made with results of experiments on the development of the boundary layer in supersonic nozzles in order to check the validity of the method.

ANALYSIS OF THE LAMINAR COMPRESSIBLE BOUNDARY LAYER CHARACTERISTICS OVER AN ISOTHERMAL FLAT PLATE WITH FINS. Adrian Pallone. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 468 (AFOSR TN 59-275) [AD 212709], Feb., 1959. 56 pp. 10 refs. Study of a method to thicken artificially the boundary layer and alter its velocity and temperature profile by means of small streamwise fins installed normal to the surface. An analysis of the compressible boundary layer characteristics is made, and the equations are reduced to a two-dimensional form by replacing the variation of all quantities in the direction normal to the plane of the fins by average values. The resulting equation is then integrated for various free-stream Mach Numbers, fin characteristics, and wall to free stream temperature ratios.

AN APPROXIMATE METHOD OF CALCULATING THE LAMINAR BOUNDARY LAYER ON A DELTA WING. J. C. Cooke. Gt. Brit., RAE TN Aero. 2595, Nov., 1958. 41 pp. Development of a method for calculating the laminar boundary layer assuming conical irrotational flow over the surface. The method is an adaptation of one due to Zaat, and depends on the momentum equations and on the assumption that the velocity in the boundary layer perpendicular to the external streamlines is small. Two variants of the method are described, depending upon the coordinate systems used.

Flow of Fluids

NEW METHODS FOR THE DETERMINATION OF VELOCITY DISTRIBUTION IN STEADY LAMINAR FLOW OF VISCOUS FLUIDS. Cr. Mateescu. Rev. Méc. Appl., No. 2, 1958, pp. 41-60. 20 refs. Analytical study of the problem of determining the velocity distribution in laminar flow emphasizing the mathematical analogy to other problems in applied mechanics. Various methods developed and their application to specific cases are discussed. Three techniques are outlined: the first, characterized by a curvilinear

network whose meshes are congruent at the contour, is applied to the flow in tubes with curvilinear cross sections and illustrated by such examples as a curvilinear quadrilateral from the Appolonius network, a half ellipse and a quarter ellipse, a section comprised between a straight line and a sinusoidal curve of infinite length, and a scalene triangle; the second is the method of superposition; and the third covers the case of drawing equal velocity curves.

EXPERIMENTAL PRESSURE DISTRIBUTIONS ON CONICAL ELLIPTICAL BODIES AT M_∞ = 3.09 AND 6.0. Victor Zakkay and Marian Visich, Jr. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 467 (AFOSR TN 59-10) [AD 208591], Mar., 1959. 31 pp. 11 refs. Presentation of pressure distribution over different angles of attack for two elliptical cones having a 16.7° equivalent circular cone and a ratio of the major to the minor axis of a/b equal to 1.39 and 1.78. A hypersonic approach similar to Newtonian is suggested for the determination of the pressure distribution. The resulting pressure distribution as determined by this method compares more favorably with the experimental results than the Newtonian theory.

EXPERIMENTAL STUDY ON THE SUPERSONIC FLOW AROUND BLUNT-NOSED BODIES OF REVOLUTION. Hakuro Oguchi. Tokyo U. Aero. Res. Inst. Rep. 341, Mar., 1959. 18 pp. 15 refs. Investigation made over a Mach Number range from 3.76 to 4.78 to determine the flow behavior ahead of four different bodies. Results show that the characteristic features of the hypersonic flow begin to appear in the flow over the blunt-nosed body of revolution at the lower Mach Number rather than that usually anticipated. The region with the local Mach Number lower than 0.5 was confirmed to spread extensively over a disturbed flow ahead of the nose. The shock wave detachment distance is nearly independent of the nose shape when referred to the radius of curvature of the shock wave. For bodies with the same nose radius, the shock-wave detachment distances are nearly independent of the position of their shoulders.

SOME STATIC, OSCILLATORY, AND FREE-BODY TESTS OF BLUNT BODIES AT LOW SUBSONIC SPEEDS. Appendix - METHOD OF COMPUTING THE DAMPING FACTOR. J. H. Lichtenstein, L. R. Fisher, S. H. Scher, and G. F. Lawrence. US, NASA Memo. 2-22-59L, Apr., 1959. 30 pp. Study of blunt-body shapes considered suitable for entry into the earth's atmosphere. Tests were made by both static and oscillatory methods in the Langley stability tunnel. In addition, free-fall tests of similar models were made in the Langley free-spinning tunnel. The results show that increasing the flare of the body shape increased the dynamic stability and that for flat-faced shapes increasing the corner radius increased the stability. Test data from the stability tunnel were used to compute the damping factor for the models tested in the free-spinning tunnel. For the cases where the damping was low, -1/2 or less, the stability was critical and sensitive to disturbance. When the damping factor was about -2, damping was generally obtained.

SUBSONIC DRAG AND PITCHING MOMENT CHARACTERISTICS OF SLENDER CAMBERED BODIES. K. D. Harris. Coll. of Aeronautics, Cranfield, Rep. 118, Sept., 1958. 38 pp. Description of experiments made at a Reynolds Number of 14.1×10^6, based on the length of the model, and a Mach Number of 0.2. Results indicate that nose camber produces a pitching moment increment in very close agreement with the predictions of inviscid slender body theory. The increments in lift and drag are small. Tail camber on the other hand gives rise to much larger lift and drag increments, and the increment in pitching moment is quite different from that predicted by inviscid theory. For the model tested the pitching moment increment due to tail camber was about 10% of the theoretical value.

THE SUPERSONIC FLOW PAST A LEADING EDGE SEPARATION BUBBLE. A. W. Sharp. J. Fluid Mech., Apr., 1959, pp. 445-459. Calculation of the supersonic flow field outside a leading edge separation bubble by a special application of the method of characteristics. Experimental observations on a two-dimensional square-nosed flat plate at a Mach Number of 1.96 formed the initial data, and base points were established on the plate surface. Computations proceeded outward and upstream to the sonic line and bow wave, the bow wave entropy gradient being taken into account. The shape of the sonic line was found to be very sensitive to the conditions along the plate surface. Streamlines and iso-Mach lines have been interpolated and are presented. Good agreement was found at the intersection of the network and the bow wave between computed values and those given directly by the shock wave equations.

CORNER INTERFERENCE EFFECTS. K. Gersten. (NATO AGARD Wind Tunnel Panel Meeting, Brussels, Mar. 2-5, 1959.) DFL Inst. Aero. Bericht No. 108, Feb. 9, 1959. 23 pp. 13 refs. Study of the incompressible fluid flow along the corner of two flat plates intersecting at right angles. The mixing of the two boundary layers produces strong interference effects. These effects are discussed, especially for the case of turbulent boundary layer, by means of experimental results. Characteristic interference parameters are introduced for describing the interference, and their dependence on the Reynolds Number is shown. The influence of interference on the transition from laminar to turbulent flow is investigated, and some preliminary results are given for the effect of pressure gradient on the interference.

LAMINARE GRENZSCHICHTEN IN DER MAGNETOHYDRODYNAMIK. G. Jungclaus. DVL Bericht No. 85, Mar., 1959. 25 pp. Westdeutscher Verlag, Köln & Opladen. In German. In-

vestigation covering laminar boundary layers in flows of electrically conducting compressible fluids in the presence of a magnetic field. Conditions are studied under which the pressure normal to the boundary layer is constant, leading to the development of a general boundary-layer theory. For very strong magnetic fields the solution is particularly simple. Similar solutions are established for the general case of magnetic fields of arbitrary strength. Mercury and liquid sodium can be used for the experimental verification of the obtained results.

SOME BASIC ASPECTS OF MAGNETOHYDRODYNAMIC BOUNDARY-LAYER FLOWS. Appendix - APPLICATION OF THE SIMPLIFIED APPROACH TO A VARIETY OF MAGNETOHYDRODYNAMIC BOUNDARY-LAYER FLOWS. R. V. Hess. US, NASA Memo. 4-9-59L, Apr., 1959. 42 pp. 14 refs. Presentation of a critical study of existing magnetohydrodynamic boundary-layer equations for stagnation flow and flat-plate flow. Certain simplifying assumptions are generally introduced into these equations, and the full implication of these has not been brought out properly. It is shown that for the particular law of deformation of the magnetic field postulated, the magnet would have to be situated in the flow away from the body to take up the induced forces resisting the flow. The boundary-layer equation is presented here in a simple form that is especially convenient for physical interpretation. This is done by adapting methods to magnetic forces which in the past have been used for forces due to gravitational or centrifugal action. The simplified approach is used to develop some new solutions of boundary flow, and an asymptotic boundary-layer solution representing a fixed velocity profile and shear is found.

RING VORTICES GENERATED ELECTROMAGNETICALLY. Chia-Shun Yih. J. Fluid Mech., Apr., 1959, pp. 436-444. Study showing that Taylor vortices occur in a fluid between concentric cylinders if a longitudinal electric current passes along the axis of the cylinders and another passes through the fluid. Specific results are given for small differences in radii. The cause of the instability is the centripetal electromagnetic body force acting on the fluid in the undisturbed state.

CHANNEL TURBULENT FLOW OF AN ELECTRICALLY CONDUCTING FLUID IN THE PRESENCE OF A MAGNETIC FIELD. P. S. Lykoudis. Purdue U. Sch. Aero. Eng. Rep. A-59-4, Mar., 1959. 19 pp. Analysis considering a system of two concentric cylinders with an annulus thickness very small compared to their average radius. An electrically conducting fluid may flow in a direction parallel to the axis of the cylinders and perpendicularly to a radial magnetic field; in this case the induced current lines will be circles lying on a plane perpendicular to the stream lines. With regard to the flow, the assumption is made that the fluid is incompressible with constant scalar transport properties. Calculations of velocity profiles, skin friction, correlation coefficients, and the distortion of the magnetic field are made for different values of the Hartmann Number.

THE PROPAGATION OF SMALL DISTURBANCES IN HYDROMAGNETICS. G. S. S. Ludford. J. Fluid Mech., Apr., 1959, pp. 387-400. AFOSR-supported study of small disturbances in a conducting gas under the influence of a uniform external magnetic field. For a perfect conductor there are three types of plane waves, each of which depends strongly on the angle at which the magnetic field is crossed. The modifying effects of finite conductivity are determined and, in the case of these waves, this is done uniformly for all angles. The free oscillations of the gas are examined when it is contained in a rectangular box and when the external field is very weak or very strong. For vanishingly weak fields the idealization of infinite conductivity proves to be inadequate. Finally, the initial-value problem is discussed.

INVISCID FLOW AROUND A BLUNT BODY OF A REACTING MIXTURE OF GASES. B - NUMERICAL SOLUTIONS. W. Lick. Rensselaer Polytech. Inst. Res. Div. TR AE 5814, Dec., 1958. 81 pp. AFOSR-supported description of an inverse method for the computation of the subsonic shock layer region. Results for three examples of the flow of air and one for the flow of pure oxygen through a prescribed shock shape at a Mach Number of 14 and for free-stream density and temperature corresponding to those of 100,000 ft. altitude are presented. For air, three shock radii are chosen so that they represent three classes of flows: (1) an equilibrium flow, (2) a nonequilibrium flow, and (3) a chemically frozen flow. These results show appreciable effects on the flow quantities due to chemical nonequilibrium. The limitations and methods of improving the accuracy of the numerical integration are discussed. A comparison of the results is also given with Freeman's nonequilibrium theory, other equilibrium theories, and experimental results.

SOME DYNAMICS PROBLEMS OF THE PUNCH METHOD OF HEATING AND ACCELERATION OF PLASMAS. H. G. Loos. Plasmadyne Corp. TN T-2TN029-335 (AFOSR TN 59-256) [AD 212256], Feb., 1959. 36 pp. Discussion of a few dynamics problems encountered in punch discharges. The fully ionized plasma is supposed to interact with the magnetic field only at the plasma boundary; the analysis is limited to time intervals in which the effect of ion-ion collisions may be neglected. The type of discharge for the basic cylindrical punch geometry depends solely on two nondimensional parameters. A scaling law is derived for changes for which these two parameters remain the same. For compressions or expansions that take place in a time short as compared with the ion-ion collision time, but which have a current sheet velocity that is small compared with the mean ion speed, the discharge coil with the moving plasma inside assumes a constant inductance.

A NEW APPROACH TO PROBLEMS OF SHOCK DYNAMICS. II - THREE-DIMENSIONAL PROBLEMS. G. B. Whitham. J. Fluid Mech., Apr., 1959, pp. 369-386. ONR-supported extension of an approximate theory developed previously to three-dimensional problems. The basic equations are derived using the original assumption of a functional relation between the strength of the shock wave at any point and the area of the ray tube. The theory is applied in detail to the diffraction of a plane shock wave by a cone. Then a small perturbation theory is applied to the two typical problems of (a) diffraction by a slender axisymmetric body of general shape, and (b) the stability of a plane shock.

SOME REMARKS ON THE SHOCK WHICH CLOSES A LOCAL SUPERSONIC REGION ON A TWO-DIMENSIONAL AEROFOIL. D. G. Randall. Gt. Brit., RAE TN Aero. 2592, Oct., 1958. 12 pp. Analysis of the nature of the flow over a profile moving at a speed which is subsonic but high enough for a closed supersonic region to appear. It is shown that no shock can exist on a convex profile in inviscid transonic flow, if the flow is assumed to be continuous and homentropic immediately upstream of the shock. Results also indicate that the positions of shocks on profiles in transonic flow are unlikely to obey the transonic similarity rules.

ON THE DRAG OF A FLAT PLATE AT ZERO INCIDENCE IN ALMOST-FREE-MOLECULE FLOW. V. C. Liu. J. Fluid Mech., Apr., 1959, pp. 481-490. 11 refs. Proposal of a theory for the skin friction on a flat plate at zero incidence in the transition flow regime - i.e., in the flow of a moderately rarefied gas. The ratio of the molecular mean free path to the characteristic size of the plate is assumed of order unity or larger. A general formula for the perturbation to the well-known friction of the free-molecule theory is given. This perturbation is attributed to the intermolecular collisions which are neglected on the basis of the free-molecule hypothesis. The expected rate of collisions is calculated for rigid spheres using the classical kinetic theory. The present theory shows that the ratio of the Reynolds Number to the square of the Mach Number is the governing parameter for determining the intermolecular collision effect on skin friction in the transition flow regime.

NOSE DRAG IN FREE-MOLECULE FLOW AND ITS MINIMIZATION. H. S. Tan. J. Aero/Space Sci., June, 1959, pp. 360-366. 17 refs. Development of a generalized approach for superaerodynamic nose drag and discussion of the specification of end conditions. Simplifications of the drag formula are obtained at hypersonic as well as low-subsonic extremes. Results indicate that in all cases an optimum nose required a flat tip. The optimum nose curve for the hypersonic extreme does not depend on the temperature ratio, but for the low-subsonic extreme varies in the following manner: for a hot body the curve is convex; for a cold body it is concave. An optimum solution exists in a restricted range of specification only. With prescribed tip and base radii the admissible nose length is bounded below for the cases of hypersonic and low-subsonic hot body and bounded above for the case of a low-subsonic cold body. A vanishing tip radius leads to an infinitely long nose in the former and a vanishing nose in the latter case.

ON THE DIFFRACTION OF AN ARBITRARY PULSE BY A WEDGE OR A CONE. Lu Ting. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 502 (AFOSR TN 59-127) [AD 210615], Feb., 1959. 12 pp. Analysis showing that the resultant velocity potential on the vertex of a wedge or a cone is simply related to that of the incidence pulse. Since the disturbance pressure is proportional to the time derivative of the velocity potential, a similar relationship between the resultant pressure and the incidence pressure is true. By virtue of Green's theorem it is shown that for the diffraction of an arbitrary two-dimensional incident pulse by a wedge of angle μ, the ratio of the resultant velocity potential to the corresponding value of the incident pulse at the corner of the wedge at any instant is equal to $2\pi/(2\pi - \mu)$; and that for the diffraction of a three-dimensional pulse by a cone of solid angle ω, the ratio at the vertex of the cone is equal to $4\pi/(4\pi - \omega)$.

Internal Flow

A NOTE ON THE CONTROL OF SECONDARY FLOW BY USING CASCADES OF TWISTED BLADES. M. E. Martin. Gt. Brit., ARC CP 425, 1959. 11 pp. BIS, New York, $0.32. Study suggesting that by varying the blade camber in accordance with the inlet velocity distribution, correction can be made for the phenomenon of overturning near the walls. It is hoped that the reduction of camber at the blade tips which this necessitates will also favorably affect the position of the separation point on the blade surfaces near the corner. Preliminary experiments demonstrating these improvements are given.

EFFECT OF CASCADE PARAMETERS ON ROTATING STALL. A. H. Stenning, B. S. Seidel, and Y. Senoo. US, NASA Memo. 3-16-59W, Apr., 1959. 33 pp. Analysis of the vortex model proposed by Kriebel, Seidel, and Schwind shows that this representation of rotating stall satisfies, at least approximately, the requirements at the cascade. Cascade-parameter-variation effects on rotating stall were studied in a circular cascade and single-stage compressor. Modification of the single-stage compressor stopped the rotating-stall pattern and permitted observation of the pressure and velocity distribution around the annulus.

AN EXPERIMENT TO DETERMINE THE POSITION OF AN EQUIVALENT ACTUATOR DISC REPLACING A BLADE ROW OF A TURBOMACHINE. J. H. Horlock and E. C. Deverson. Gt. Brit., ARC CP 426, 1959. 6 pp. BIS, New

York, $0.24. Investigation in which axial velocity profiles are measured at many axial locations upstream and downstream of a moving row. Changes in axial velocity outside the row are compared with the exponential decay of axial velocity perturbations predicted by simple actuator disc theory. It is found that the simple theory gives adequate prediction of the observed axial velocities if the disc is located near the axial centerline of the blades.

TWO-DIMENSIONAL OBLIQUE SHOCK CALCULATIONS IN A HYPERSONIC DIFFUSER. Appendix - TYPICAL CALCULATIONS FOR THE INITIAL CONDITION OF AN ALTITUDE OF 150,000 ft. AND A MACH NUMBER OF 15 AT A DEFLECTION ANGLE OF 28°. Tung Chen. Purdue U. Sch. Aero. Eng. Rep. A-58-7, Nov., 1958. 25 pp. Analysis to determine the dissociation effect on recovery pressure in order to assess the advantage of the oblique shock configuration over the normal shock diffuser. The typical case of a sequence of two oblique shocks is studied using a graphical method developed by Bird. Calculations of recovery pressure are carried out on the basis of two conditions at the test section, one for an altitude of 100,000 ft. with a Mach Number of 10, and the others for an altitude of 150,000 ft. with a Mach Number of 15.

HYDRODYNAMIC STABILITY OF A JET. L. N. Howard. J. Math. & Phys., Jan., 1959, pp. 283-298; Discussion, J. Moser, pp. 299-304. Analysis of the stability of a two-dimensional jet in a viscous incompressible fluid. The Orr-Sommerfeld equation for small Reynolds Number R and small wave number of instability α is examined, and the lower part of the neutral stability curve is calculated. The method provides a formal expansion of the lowest eigenvalue $c = c(\alpha)$ and the corresponding eigenfunction ϕ for a fixed R.

CALCULUL ANALITIC AL UNEI CLASE DE EFUZOARE SUPERSONICE PLANE, CU PANTA MICĂ ÎN VECINĂTATEA COLULUI SONIC. M. M. Paloş. Stud. Cerc. Mec. Aplic., No. 3, 1958, pp. 545-558. In Rumanian, with summaries in Russian and French. Analytical calculation of a class of two-dimensional expanding supersonic nozzles. The investigation is divided into three parts: (a) study of the motion defined by the flow function as a solution of the Molenbroek-Chaplygine equation; (b) derivation of equations for the expanding nozzle profile; and (c) discussion of the sonic throat and presentation of a design method. A practical method of calculation is indicated. This method is based on the transformation of the supersonic flow, defined by the flow function in the region between the sonic throat and the last characteristic in the uniform and parallel supersonic flow following the last Mach line where the velocity corresponding to the desired Mach Number is attained. This transformation is made possible by adjoining the motion of two domains to a third, intermediary one, where the motion takes place in the form of simple waves. The limitations of the method are outlined and its application to the calculation of nozzles for $M_1 \leq 2.6$ is outlined.

REFLECTION OF WEAK SHOCK WAVES FROM NOZZLES WITH NO FLOW AND CRITICAL FLOW. Ch. E. Feiler. ARS J., Apr., 1959, pp. 272-275. Study using a shock tube with nozzles that have contraction ratios of 16, 4, and 2, and convergence half-angles of 60°, 30°, and 15°. The experiments were performed with no initial flow through the nozzle and also with critical flow, and the results compared with theory. Contraction ratio, as predicted by theory, had much less effect on reflected shock strength with critical flow through the nozzles than with no initial flow. Convergence angle had little effect on reflected shock strength of either flow condition.

Jet Flaps & Wings

WIND-TUNNEL INVESTIGATION OF A SMALL-SCALE SWEPTBACK-WING JET-TRANSPORT MODEL EQUIPPED WITH AN EXTERNAL-FLOW JET-AUGMENTED DOUBLE SLOTTED FLAP. J. L. Johnson, Jr. US, NASA Memo. 3-8-59L, Apr., 1959. 41 pp. Experimental investigation at low speeds to study the aerodynamic characteristics of the jet-transport model. Tests of the wing alone to determine the effects of varying the spanwise extent of blowing on the full-span flap are included. Results indicate that the double-slotted-flap arrangement of the present investigation is more efficient in terms of lift and drag than the single-slotted-flap arrangements previously tested. The double-slotted configuration gives a substantial reduction of the thrust-weight ratio required for a given lift coefficient under trimmed drag conditions. An increase in the spanwise extent of blowing on the full-span flap is found to increase the efficiency of the model in terms of lift and drag, but is accompanied by significant increases in negative pitching moment.

Stability & Control

THE PRESENT STATUS OF AIRCRAFT STABILITY PROBLEMS IN THE AEROELASTIC DOMAIN. Appendix - ELASTIC-INERTIA COUPLING TERMS IN THE "SEMI-RIGID" EQUATIONS OF LONGITUDINAL MOTION OF A FLEXIBLE AIRCRAFT. A. S. Taylor. RAeS J., Apr., 1959, pp. 227-238. 22 refs. Discussion of recent developments in the study of the effects of structural flexibility on aircraft stability and control with particular reference to dynamic stability. The relevant literature, relating to both theoretical and experimental work, is reviewed with a view of assessing the importance of those effects and establishing how elaborate a mathematical treatment is necessary to predict them with reasonable accuracy. The advantages of an integrated approach to this and associated aeroelastic problems, whereby the solutions to several related problems may be obtained as special cases of a more generalized problem, are briefly discussed.

THE AERODYNAMICS OF BODIES IN NON-UNIFORM FLOW. I - THE AERODYNAMICS OF AIRFOILS IN NON-UNIFORM STREAMS: INCOMPRESSIBLE FLUID. Enrico Pistolesi and Marino Marini. U. Pisa Inst. Aero. TN 1 (AFOSR TN 59-111) [AD 210391], 1959. 18 pp. Study of the aerodynamic behavior of an airfoil immersed in a bidimensional stream adjacent to another of different velocity. Various simplifying assumptions are made. The problem is solved by using the classical method of conformal mapping. The values of the velocities induced on the interface between the two streams and on the rigid wall are deduced, and the aerodynamic effects on the airfoil are determined. The ratio L/L_0 between the real value of the lift and the one that would result for the airfoil in uniform stream is found to decrease with the ratio k between the velocities of the two streams.

THE AERODYNAMICS OF BODIES IN NON-UNIFORM FLOW. II - THE AERODYNAMICS OF AIRFOILS IN NON-UNIFORM STREAMS: SUBSONIC AND SUPERSONIC STREAMS. Enrico Pistolesi and Marino Marini. U. Pisa Inst. Aero. TN 2 (AFOSR TN 59-112) [AD 210392], 1959. 20 pp. Analysis of an airfoil situated in a subsonic stream adjacent to a supersonic stream that consists of a stream of finite width bounded at the lower side either by a rigid wall, or by a jet of finite width. In the first case, the values of the velocities at the interface of the two streams and at the wall are determined; in the second, the velocity at the interface and on the jet axis are found. After calculating the values of the velocities induced in the aerodynamic center of the airfoil, the values of the ratios between the real values of the circulation and lift, and the corresponding values for the airfoil in a uniform stream, are deduced.

ASUPRA REZOLVĂRII PROBLEMEI LUI PRANDTL GENERALIZATĂ. N. N. Patraulea. Stud. Cerc. Mec. Aplic., No. 3, 1958, pp. 525-536. 13 refs. In Rumanian, with summaries in Russian and French. Derivation of a solution to the generalized Prandtl problem reduced to that of an integral Fredholm equation in the D domain. The specific applications of the Prandtl problem are indicated, and an analogy is drawn between the case of a jet flap and that of a wing of semi-infinite span. Numerical methods of solution are presented, as well as those based on the electric analogy.

STUDIUL ARIPILOR TRIUNGHIULARE SUBŢIRI CU SIMETRIE FORŢATĂ ÎN CURENT SUPERSONIC. Elie Carafoli and Adriana Năstase. Stud. Cerc. Mec. Aplic., No. 4, 1958, pp. 833-853. In Rumanian, with summaries in Russian and French. Study of thin triangular wings of forced symmetry governing the variation of incidence and, consequently, the vertical velocity w over the wing. The variation of the vertical component w of the turbulent velocity over the wing is given in the form of a higher-order homogeneous polynomial, and the expression for the axial turbulent velocity u, proportional to the pressure coefficient, is determined. Based on the general formula of this axial velocity u, a method is indicated for calculating the constants included in the transition from the homogeneous motion of the order of (n-1) to that of the order of n. Applications are made to motions of the order of n=2, 3, 4. Also included is a calculation of aerodynamic characteristics (lift and wave drag) of symmetrical wings, as well as the suction force appearing along the edges of thin subsonic wings. The derived formulas can be used to determine the aerodynamic characteristics for wings of natural symmetry.

THE CALCULATION OF INTERFERENCE DRAG BETWEEN WING LIFT AND FUSELAGE THICKNESS AT SUPERSONIC SPEEDS. E. W. Graham and R. M. Licher. Douglas Rep. SM-23446, Feb., 1959. 23 pp. 22 refs. Analysis of an elliptical plan form, zero thickness wing combined with a Sears-Haack fuselage in order to determine the variation of drag with wing height above the fuselage centerline. The method of analysis applies both when the wing lies within the Mach envelope of the fuselage and when it extends outside the envelope. For both cases the drag values obtained are compared with those for the midwing configuration. It is shown that the drag of the elliptic high wing and Sears-Haack fuselage is less than that of the same midwing configuration. For small parameters of the height parameter h, the drag reduction is linear in h. A second problem considered is the possibility of further drag reductions through modification of the fuselage thickness distribution. The total drag of the fuselage and high wing is computed and then optimized to determine the best proportions for the modified fuselage.

A NUMERICAL METHOD FOR CALCULATING THE WAVE DRAG OF A CONFIGURATION FROM THE SECOND DERIVATIVE OF THE AREA DISTRIBUTION OF A SERIES OF EQUIVALENT BODIES OF REVOLUTION. Appendix A - DIMENSIONLESS ZERO-LIFT WAVE-DRAG EQUATIONS. Appendix B - EVALUATION OF THE INTERFERENCE INTEGRAL FOR PAIRS OF BODIES OF REVOLUTION. Appendix C - AN ANALYTICAL APPROXIMATION OF AIRFOIL-SECTION AND PLAN-FORM THICKNESS DISTRIBUTIONS. Appendix D - AN APPROXIMATE ANALYTICAL METHOD FOR CALCULATING AREA DISTRIBUTIONS AND THEIR DERIVATIVES FOR SHEARED WINGS OR TAIL SURFACES. Appendix E - A PROCEDURE FOR CALCULATING LIFT DISTRIBUTIONS FOR SHEARED WINGS. L. L. Levy, Jr., and K. K. Yoshikawa. US, NASA Memo. 1-16-59A, Apr., 1959. 91 pp. 10 refs. Development of a method, based on linearized and slender-body theories, for calculating the zero-lift wave drag of single- and multiple-component configurations. The accuracy and computational time required for wave drag calculations

is compared to that of another numerical method employing the Tchebysheff form of harmonic analysis. Results indicate that for systems of bodies of revolution both methods yield similar results with comparable accuracy; however, the present method only requires up to 60% of the computing time required by the harmonic analysis method for two bodies of revolution and less time for a larger number of bodies.

IMPROVING THE ACCURACY OF PRESSURE DISTRIBUTIONS IN LINEARISED SUPERSONIC WING THEORY. Appendix - ALTERNATIVE METHOD OF DERIVING IMPROVED WING PRESSURE DISTRIBUTIONS. L. M. Sheppard. Australia, WRE TN HSA 45, Jan., 1959. 13 pp. 10 refs. Analysis considering simpler methods for obtaining pressure distributions on three-dimensional supersonic wings starting from the first-order, or linearized, pressure distribution. A method based on the second-order theory of two-dimensional supersonic airfoils is recommended. This method has been applied to a flat plate delta wing with "supersonic" edges and the modified pressure distribution shows good agreement with the exact theoretical pressure distribution.

THE AERODYNAMICS OF BODIES IN NON-UNIFORM FLOW. III - THE AERODYNAMICS OF AIRFOILS IN NON-UNIFORM SUPERSONIC STREAMS. Enrico Pistolesi and Marino Marini. U. Pisa Inst. Aero. TN 3 (AFOSR TN 59-113)[AD 210393], 1959. 43 pp. Analysis considering an airfoil situated in a two-dimensional supersonic stream that is adjacent to another supersonic stream with a different velocity. The small perturbation theory is used in the study, the airfoil being considered as a flat plate having a small angle of attack within the stream. The effect of reflection of Mach waves at the interface of the two streams is considered in each of the following cases: (a) an airfoil situated in a semi-infinite stream adjacent to another semi-infinite stream; (b) an airfoil situated in a semi-infinite stream near the discharge of a jet, its pressure at the discharge section being equal to the asymptotic pressure of the exterior stream; and (c) an airfoil situated near a jet with a discharge pressure different from that of the exterior stream.

PROBLEMES MIXTES DES AILES TRIANGULAIRES POURVUES D'UNE PLAQUE NORMALE, EN COURANT SUPERSONIQUE (AILES CRUCIFORMES). Elie Carafoli and Béatrice Horovitz. Rev. Méc. Appl., No. 3, 1958, pp. 185-197. (Also in Stud. Cerc. Mec. Aplic., No. 4, 1958, pp. 819-832.) In French. Study of certain mixed problems in the case of high-speed homogeneous flow around cruciform wings. The problems are arranged in the following manner: (1) when such parameters as the pressures over the wing and the shape of the plate (incidence or slope) are introduced -- the incidence or the slope of the wing and the pressure distribution over the plate are determined; (2) when the shape of the wing (incidence or slope) and the pressures over the plate are the given parameters -- the incidence or the slope of the plate and the pressure distribution over the wing are determined. On the basis of the theory of small perturbations it is known that the pressure distribution is proportional to the axial component u of the turbulent velocity; the shape of the wing is a function of the component w, normal to the wing; and the shape of the wing is a function of the component v, normal to the plate.

AEROELASTICITY

PREDICTED STATIC AEROELASTIC EFFECTS ON WINGS WITH SUPERSONIC LEADING EDGES AND STREAMWISE TIPS. Appendix A - DERIVATION OF EQUATIONS FOR AERODYNAMIC LOADING. Appendix B - DIFFERENTIATING AND INTEGRATING FACTORS USED FOR NUMERICAL EXAMPLE. S. C. Brown. US, NASA Memo. 4-18-59A, Apr., 1959. 38 pp. 14 refs. Presentation of a method for calculating aerodynamic influence coefficients by means of the linearized supersonic wing theory. The calculation of static aeroelastic effects through the use of these aerodynamic influence coefficients, together with a set of structural influence coefficients which may include chordwise bending, is also developed. Sample calculations were made of the influence of flexibility on the effectiveness of several lateral-control devices and also on several stability derivatives for a low-aspect-ratio configuration.

TRANSONIC EFFECTS ON T-TAIL FLUTTER. Appendix - SUMMARY OF STIFFNESS AND MASS PROPERTIES OF THE MODELS. C. V. Stahle. Martin RM 24, Feb., 1959. 50 pp. Investigation of the transonic effects of stabilizer dihedral and hull stiffness on the flutter characteristics of T-tails. Experimental data are presented on the antisymmetric flutter characteristics and the subcritical behavior of T-tails in the transonic range, and a spectrum analysis technique is described for determining the subcritical behavior from the model response to tunnel turbulence. The response spectra were obtained from analysis of magnetic tape records and were combined with turbulence data to provide damping trends. Ten dynamically similar models having stabilizer dihedral angles of 0°, 15°, and 30° were tested from Mach 0.5 to 1.15. The flutter mode of all models tested was predominated by fin bending and hull lateral bending motion, and the flutter condition was characterized by the convergence of the frequencies of the first and second modes. A gull stabilizer unit with 15° positive dihedral at the root section and 15° negative dihedral at the tip section was tested. The results indicate that the flutter point of the gull configuration is 15% higher than that of the 15° dihedral models, but it is lower than the flutter boundary of the models without dihedral.

DETERMINATION DES COEFFICIENTS AERODYNAMIQUES INSTATIONNAIRES SUR UNE AILE DELTA DE MACH = 0 A MACH = 1,35. R. Dat and R. Destuynder. France, ONERA NT 52, 1959. 15 pp. In French. Wind-tunnel measurement of

nonstationary aerodynamic coefficients by means of a classical method. The limitations of the method are indicated, and the apparatus used is described. The results are used to calculate several cases of flutter in the transonic region. Includes comparison of the performance curves to experimental results obtained on various types of models.

ENERGY DISSIPATION IN LONGITUDINAL VIBRATION. C. S. Chang and L. E. Goodman. USAF WADC TR 58-36 [AD 155705], July, 1958. 40 pp. Derivation of a solution for the forced and free vibrations of a bar with a terminal dashpot subject to arbitrary excitations and initial conditions. This procedure is equivalent to integrating along the characteristics of the governing differential equation. The general solution is then applied to examples that show the significant role played, by dashpot strength as a physical parameter.

AIRPLANES

Design

SEVERAL METHODS FOR REDUCING THE DRAG OF TRANSPORT CONFIGURATIONS AT HIGH SUBSONIC SPEEDS. R. T. Whitcomb and A. R. Heath, Jr. US, NASA Memo. 2-25-59L, Mar., 1959. 12 pp. Review of some of the more promising drag reduction methods including a wing leading-edge extension, a localized fuselage addition, and additions on the wing. Results are presented for a complete, improved transport configuration which incorporates the fuselage and wing additions and show that the improved configuration could have considerably higher cruise speeds than do current designs.

CHEMISTRY

A GENERAL METHOD FOR CALCULATING THE EQUILIBRIUM COMPOSITION OF GASEOUS MIXTURES FOR THE C-H-O-N-SYSTEM (TEMPERATURE RANGE: 800°K TO 4000°K). W. Gohrbandt. Gt. Brit., NGTE Rep. R.227, Dec., 1958. 82 pp. Presentation of a method applicable for hydrogen/carbon ratios from zero to infinity at all pressures where the ideal gas law is valid and includes, where relevant, the formation of atomic nitrogen, methane, and solid carbon. The independent variable upon which the calculation is based is the partial pressure of oxygen. The calculation may be made for any equivalence ratio. Additional data are presented for calculation of the composition of rich mixtures as an aid to the determination of turbo-rocket performance and the study of gasification processes.

FUELS & LUBRICANTS

SOME THERMAL STRESS DESIGN DATA FOR ROCKET GRAINS. M. L. Williams. ARS J., Apr., 1959, pp. 260-267. 18 refs. Presentation of design data for thermal stresses in the particular case of a steady-state temperature difference across the grain, or for a specified heat flux. After determining the internal temperature using a voltage analogy, the Biot-Muskhelishvili analogy is employed to transform the thermal stress field into an equivalent temperature independent edge dislocation problem. The approximate displacements are then applied to a series of photoelastic specimens of slotted grains, and the stress rise over that existing in a thick walled cylinder of the same web is evaluated experimentally.

MATERIALS

Metals & Alloys

CYCLIC CREEP BUCKLING OF INTEGRALLY STIFFENED ALUMINUM ALLOY PANELS. C. W. King and B. J. Nolan. USAF WADC TR 58-38 [AD 155834], Apr., 1958. 110 pp. 26 refs. Investigation of the applicability of a hypothesis on cumulative damage to intermittent cycles of creep loading on aluminum alloys. A comparison is made on creep buckling lifetimes for intermittent loading tests with continuous load tests for creep buckling specimens; a similar comparison is made for tension creep specimens with a master rupture parameter. The buckling specimens consisted of identical upper and lower sculptured skin panels mounted as tension and compression surfaces, repectively, of an open-sided box beam loaded with equal end moments. Test results indicate poor correlation of cumulative time-to-failure to uninterrupted time-to-failure for buckling tests, and also for tension tests where comparisons are made by use of the master rupture parameter. In general, the cyclic creep buckling tests resulted in lower lifetimes than equal environment continuous type tests.

MISSILES, ROCKETS

STUDY OF THE OSCILLATORY MOTION OF MANNED VEHICLES ENTERING THE EARTH'S ATMOSPHERE. S. C. Sommer and Murray Tobak. US, NASA Memo. 3-2-59A, Apr., 1959. 30 pp. Derivation of expressions for oscillatory motion as continuous functions of the properties of the prescribed trajectory through the atmosphere. Results are applied to a study of the oscillatory behavior of re-entry vehicles which have decelerations that remain within limits of human tolerance. It is found that, for a deficiency of aerodynamic damping, the factor governing the seriousness of the divergent oscillations which occur is the altitude at which dynamic pressure is a maximum. The decelerations of manned vehicles are maintained within tolerable limits by the use of small initial flight-path angles or by the use of lift. Since both tend to raise the altitude at which dynamic pressure is maximum, it is concluded that the dynamic stability problem of manned nonlifting vehicles deficient in aerodynamic damping may be more severe than that of comparable ballistic missiles.

INTERPLANETARY TRAJECTORIES UNDER LOW THRUST RADICAL ACCELERATION. Jack Copeland. ARS J., Apr., 1959, pp. 267-271. Calculation of interplanetary trajectories resulting

from constant radial acceleration (toward or away from the sun), and presented in terms of tabulated functions. For sustained acceleration greater than a critical value, the vehicle spirals to escape. For accelerations less than critical, the vehicle moves in precessing orbits with perihelion or aphelion on the initial orbit using outward or inward thrust, respectively. Some examples of trajectories are given and their implications discussed.

OPTIMUM TRAJECTORIES IN UNIFORM AND "ALMOST UNIFORM" GRAVITATIONAL FIELDS. E. W. Graham. Douglas Rep. SM-23430, Feb., 1959. 30 pp. Study of problems involving the transfer of a rocket vehicle from one point to another with minimum fuel expenditure. The rocket vehicle is assumed to operate in a gravitational field without atmospheric resistance. The transfer time and the terminal velocity vectors are specified. If the magnitude and direction of the gravitational force are everywhere constant (a uniform field), then the fuel required is a minimum if impulses are applied only at the terminals. For centrally directed fields, the result is extended to certain problems in which the field is effectively "almost uniform." A dimensionless parameter P involving the strength of the gravitational field and the prescribed transfer time is used to measure the importance of the nonuniformity of the gravitational field.

TRADE-OFF CONSIDERATIONS IN THE DESIGN OF GUIDANCE EQUIPMENT FOR SPACE FLIGHT. Ch. J. Mundo, Jr. Aero/Space Engrg., June, 1959, pp. 31-34. Study of the problems that arise in the interaction between the guidance and propulsion essential for the optimum performance of a system designed to fulfill a photographic graze mission in near interplanetary space. The acceleration pattern of the propulsion system interacts with the acceleration sensitive guidance measurements in two ways: the first involving a rotation of the reference coordinates with respect to their initial alignment in space; the second involving direct nonlinearity in the acceleration sensitivity of the instrument itself. These errors are formulated in terms of a series expansion of the acceleration undergone by the missile.

THE SYNTHESIS OF OPTIMUM HOMING MISSILE GUIDANCE SYSTEMS WITH STATISTICAL INPUTS. Appendix A - DETERMINATION OF THE OPTIMUM HOMING CONTROL SYSTEM. Appendix B - DETERMINATION OF THE OPTIMUM RANGE MULTIPLICATION HOMING CONTROL SYSTEM WITH CONTROL MOTION RESTRICTION. E. C. Stewart and G. L. Smith. US, NASA Memo. 2-13-59A, Apr., 1959. 57 pp. Presentation of an analytical approach applicable to the optimization of homing missile guidance systems operating in the presence of radar noise. The factors considered are (1) target evasive maneuver, (2) radar glint noise, (3) missile maneuverability, and (4) the inherent time-varying character of the kinematics. Although an exact analytical solution does not appear to be feasible, approximate solutions utilizing time-varying control systems can be found. One of these solutions, a range-multiplication type control system, is studied in detail. The effect of changes in target acceleration, noise magnitude, and missile acceleration on the minimum miss distance is considered.

ON-OFF CONTROL SYSTEM FOR ATTITUDE STABILIZATION OF A SPACE VEHICLE. J. S. Pistiner. ARS J., Apr., 1959, pp. 283-289. Development of certain nonlinear analysis and synthesis techniques as applied to an on-off control system for attitude stabilization of a space vehicle. As an example of the possible application of the theory, a hydrogen peroxide system is discussed. It is shown how the analysis effort is simplified when vehicle attitude and attitude rate are represented by a set of nondimensional position-velocity coordinates defining a "phase plane." The requirement for compensation (lead) networks to achieve stable limit cycle operation is established, and the effect of time delays on system performance is discussed. Since fuel consumption is shown to be dependent on lead network configuration, a synthesis method for optimization of the compensation network to result in minimum fuel consumption is presented.

PHYSICS

RADIATION FROM HOT AIR. Appendix - APPROXIMATION TO THE CONDON FACTORS FOR O_2 SCHUMANN-RUNGE SYSTEM. J. Keck, J. Camm, B. Kivel, and T. Wentink, Jr. Avco Res. Lab. RR 42, Feb., 1959. 62 pp. 35 refs. USAF-sponsored study of the radiation emitted by shock-heated oxygen, nitrogen, and air in the wavelength range of 2,000 to 10,000Å at temperatures from 4,000° to 9,000°K. and densities from 0.01 to 10 times standard atmospheric. Both spectroscopic and photometric techniques are employed. The radiation consists of bands from O_2, N_2, N_2^+, and NO molecules, and lines from O and N atoms. Comparison of the experimental results with theoretical expressions, giving the wavelength, temperature, and density dependence of the radiation gives electronic f-numbers for all the bands observed.

POWER PLANTS

ÜBER ARBEITSGASE FÜR NICHT KONVENTIONELL BEHEIZTE RAKETEN. Irene Sänger-Bredt. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 2, 1959, pp. 97-115. 37 refs. In German. Study of working fluids for unconventionally heated rocket engines. The various rocket types possible and their attainable specific impulses are reviewed, and the "working fluid" concept and its functions are defined. The values of the functions of thermodynamic mixtures are presented for equilibrium conditions of some hydrogen-oxygen working fluid mixtures. Mean molecular weights, degree of ionization, and specific impulses obtainable for heating and flow processes are derived. The processes taking place during heating of the working fluids through the bombard-

ment by corpuscular beams are considered and a systematic investigation program is proposed.

STRAHLUNGSQUELLEN FÜR PHOTONEN-STRAHLANTRIEBE. Eugen Sänger. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 1, 1959, pp. 15-25. In German. Comparative evaluation of the sources of radiation for photon propulsion in terms of its application to space travel at speeds possibly exceeding one million km./h. Gas plasmas of sufficiently high radiation pressure, composed of elements from the upper part of the periodic table of elements, are considered as sources of radiation at temperatures in the neighborhood of 150, 000°K. These plasmas may produce an approximately black radiation for technically conceivable optical layer thicknesses. Included are such factors as the transition region from conventional aviation to interstellar flight, covering the characteristic parameters, flight velocities, and flight altitudes relative to the earth; biological conditions limiting the flight in space; and illustrative examples of plasma types.

ELECTRICAL PROPULSION SYSTEMS IN SPACE FLIGHT. L. R. Shepherd. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 2, 1959, pp. 144-157. 14 refs. Examination of possible forms of propulsion units with particular regard to specific mass. Various criteria suggest that the overall specific mass of the propulsion system should not exceed 0.5 tons per megawatt. Existing electrical generating equipment is shown to be far too massive for application to propulsion of space vehicles. It is suggested that for the production of relatively low specific impulses of 10, 000 sec. or less a magnetic accelerator which accelerates a neutral plasma may be superior to the conventional accelerator in which separated positive ions are accelerated in an electrostatic field. The possibility of a vehicle utilizing a plasma generator coupled to a magnetic accelerator using sodium as a propellant is discussed.

A 20, 000-KILOWATT NUCLEAR TURBOELECTRIC POWER SUPPLY FOR MANNED SPACE VEHICLES. Appendix A, B - EQUATIONS FOR RATIO OF RADIATOR AREA TO ELECTRIC POWER OUTPUT. Appendix C - HEAT-EXCHANGER DESIGN FOR A 20, 000-KILOWATT ELECTRIC OUTPUT. Appendix D - CONDENSER-RADIATOR ANALYSIS. Appendix E - TURBINE DESIGN. R. E. English, H. O. Slone, D. T. Bernatowicz, E. H. Davison, and Seymour Lieblein. US, NASA Memo. 2-20-59E, Mar., 1959. 65 pp. 27 refs. Study indicating that the radiator necessary for rejecting cycle waste heat is the dominant weight and emphasizing the selection of cycle operating conditions in order to reduce this weight. A thermodynamic cycle using sodium vapor as the working fluid and operating at a turbine-inlet temperature of 2, 500°R. was selected. The total powerplant weight was calculated to be approximately 6 lbs. per kilowatt. The radiator necessary for rejecting cycle waste heat contributes approximately 2.1 lbs. per kilowatt to the total weight, whereas the reactor and reactor shield contribute approximately 0.24 and 1.2 lbs. per kilowatt, respectively.

PLASMA PROPULSION DEVICES FOR SPACE FLIGHT. M. Camac, A. Kantrowitz, H. E. Petschek. Avco Res. Lab. RR 45, Feb., 1959. 40 pp. USAF-supported analysis of some of the more immediate space missions indicates that a large increase in payload can be achieved when electrical propulsion is used instead of chemical propulsion. For missions in the gravitational field of the earth and the moon, the optimum specific impulse range for electrical propulsion is from about 1, 500 sec. to 5, 000 sec. Electrical propulsion with neutral plasma devices operates well in this specific impulse range as well as at higher specific impulses. Three different chambers are described as examples of devices using neutral plasmas. Some of the factors which limit the range of efficient operation of such devices are discussed.

Rocket

COMBUSTION INSTABILITY IN SOLID PROPELLANT ROCKET MOTORS. E. W. Price. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 1, 1959, pp. 63-72. Discussion of combustion instability considering the manifestations of the phenomenon, the environment in which instability occurs, and the elements of the instability mechanism. The detection of combustion instability by measurement of oscillation in pressure, temperature, and radiation is examined, and recording methods are discussed. The phase relations that must exist for excitation and the source of the phase lag are explained. Finally, three methods for the suppression of instability are discussed. The method of acoustic interference involves the use of geometries such that no natural modes of the combustion chamber are easily excited. The second concerns viscous damping and temperature damping. The last considers the blocking of excitations by an addition of a suppressant such as carbon or aluminum oxide.

LE FACTEUR DE DEBIT, CARACTERISTIQUE DE LA QUALITE DE LA COMBUSTION DANS UN PROPULSEUR-FUSEE. Wolfgang Zangl. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 2, 1959, pp. 87-96. In French. Study of the parameters influencing the combustion in a rocket motor. Starting from a definition of the flow-rate coefficient, its usefulness for estimating the quality of the combustion is deduced. A comparison between the flow rate coefficient and the flow rate per unit area of the throat shows the advantages of using the former for problems dealing with relative values and the latter for absolute value problems. The effects of the combustion chamber and of the injection system are considered, and the influence of the various dimensional parameters on the flow rate coefficient are shown. On the basis of the relations found, a rocket motor for optimum

condition can be designed and the flow rate coefficient calculated in advance.

RESEARCH, RESEARCH FACILITIES

Wind Tunnels

A THEORETICAL INVESTIGATION ON THE USE OF COMBUSTION PRODUCTS FOR THE SIMULATION OF HYPERSONIC FLOW. V. D. Agosta. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech. Rep. (USAF WADC TN 59-81) [AD 211916], Mar., 1959. 23 pp. 13 refs. Calculation of condensation limits for various fuel-air combinations in order to insure vapor-free flow. For a particular case investigated the ratios of pressures, specific heats, Mach Number, and Reynolds Number closely simulate Mach Number 7 flight at 100,000 ft. altitude in the atmosphere. The influence of scale on pressure distributions and forces, and the influence of viscous effects can be investigated using combustion gases.

ROTATING WING AIRCRAFT, HELICOPTERS

STUDY OF HELICOPTER STRUCTURAL DESIGN CRITERIA. A. R. Yackle, J. A. Gaidelis, and A. A. Perlmutter. USAF WADC TR 58-336 [AD 202531], May, 1958. 92 pp. 42 refs. Study of present methods used in determining helicopter structural design criteria and recommendation of optimum means for specifying the strength requirements. Present day requirements are derived from criteria 10 to 15 years old, most of which come from fixed wing aircraft and autogiro experience. The specifications emphasize static loads with little regard for dynamic loads or fatigue type conditions. The military specifications are reviewed to determine (a) what parts may still be applicable, and (b) what parts require further study. For those parts requiring further study, a recommended solution is shown. All major components of the helicopter are considered with the exception of the main rotor.

WIND-TUNNEL INVESTIGATION OF THE EFFECT OF ANGLE OF ATTACK AND FLAPPING-HINGE OFFSET ON PERIODIC BENDING MOMENTS AND FLAPPING OF A SMALL ROTOR. J. L. McCarty, G. W. Brooks, and D. J. Maglieri. US, NASA Memo. 3-3-59L, Mar., 1959. 44 pp. 16 refs. Test results showing that the blade periodic bending moments generally increase with tip-speed ratio up into the transition region, diminish over a certain range of tip-speed ratio, and increase again at higher tip-speed ratios. Above the transition region, the bending moments increase with collective pitch angle and rotor angle of attack. The absence of a flapping hinge results in a significant amplification of the periodic bending moments, the magnitudes of which increase with tip-speed ratio. When the flapping hinge is used, an increase in flapping-hinge offset results in reduced period bending moments. The existence of substantial amounts of blade stall increased both the periodic bending moments and the flapping angles.

CALCULUL DE REZISTENŢĂ A PALELOR DE ELICOPTER DE SECŢIUNE CONSTANTĂ SUB O SARCINĂ DATĂ. A. Petre. Stud. Cerc. Mec. Aplic., No. 3, 1958, pp. 711-719. In Rumanian, with summaries in Russian and French. Calculation of the strength of helicopter rotor blades of constant cross section subjected to a given loading. The rigorous differential equation for the elastic line is derived taking into account the additional loading due to deformation. The equation is then integrated, thus leading to an exact solution of the problem. The derived expressions include also the flexural moments. The solution is presented in the form of hypergeometric or Lommel functions, depending on the various conditions of blade fixing.

COMPARISON OF MEASURED FLAPWISE STRUCTURAL BENDING MOMENTS ON A TEETERING ROTOR BLADE WITH RESULTS CALCULATED FROM THE MEASURED PRESSURE DISTRIBUTION. A. P. Mayo. US, NASA Memo. 2-28-59L, Mar., 1959. 32 pp. Study made in the hovering condition as well as two forward-flight conditions. The results show that the relatively rapid theoretical method used provides adequate agreement for fatigue-study purposes between the bending moments measured by strain gages and those calculated from pressure measurements. Some comparisons between the experimental and calculated blade stiffnesses and natural frequencies are also included.

METOD RASCHETA DINAMICHESKOI USTOICHIVOSTI PRI VISENII GELIKOPTERA, OSNASHCHENNOGO NESUSHCHIMI VINTAMI S LOPASTIAMI KANTILEVERA. A. Marinesku. Rev. Méc. Appl., No. 2, 1958, pp. 23-39. In Russian. Development of a method for calculating the dynamic stability in hovering flight for helicopters equipped with lifting rotors having cantilever blades. The types studied include single-rotor and double-rotor helicopters, the latter having coaxial, counterrotating blades. The variation of the oscillation period observed for both types indicates that, in order to obtain the desired increase in the period of unsteady oscillations, the center of gravity of the helicopter should be located as near the shaft of the lifting rotor as possible. The factors considered include the rotation of the helicopter around the center of gravity and the gyroscopic effect of the rotor.

SPACE TRAVEL

SCIENTIFIC PROBLEMS IN CISLUNAR SPACE AND THEIR EXPLORATION WITH ROCKET VEHICLES. S. F. Singer. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 2, 1959, pp. 116-125. 12 refs. Discussion of scientific measurements which can be carried out in the "cislunar" region. Stress is placed on such problems as the space distribution and intensity of cosmic rays, auroral particles, and other corpuscular radiations some of which might be responsible for the magnetic storm producing ring current. The earth's outer

atmosphere and gravitational field effects of earth and moon are considered. The moon's magnetic field and measurements of the lunar atmosphere and lunar tidal bulge are discussed.

INFLUENŢA REGIMULUI DE TRACŢIUNE ASUPRA PERFORMANŢELOR UNEI RACHETE LANSATE TANGENŢIAL DE PE UN SATELIT ARTIFICIAL. Lucian Dumitrescu and Traian Comănescu. Stud. Cerc. Mec. Aplic., No. 3, 1958, pp. 537-544. In Rumanian, with summaries in English and Russian. Study of the motion of a space rocket taking off from an artificial earth satellite. The following assumptions are introduced: (a) the thrust magnitude remains constant throughout the combustion time and (b) its direction remains tangential to the satellite orbit. The differential equations of motion are solved approximately by means of an iteration process. The resulting expressions for the radial and angular velocities v_r, ω and for the radius r, are then inserted into the formula which defines the performance index h. It is shown that h is a function of the mass ratio μ and the thrust magnitude. The numerical examples presented show that the best performance, with a given fuel consumption, is obtained when the burning-out is instantaneous, but that the loss of performance following the adoption of a more convenient thrust regime is not severe in comparison with the practical advantages of such a procedure. Numerical comparison with previous studies covering the case of a rocket whose thrust is acting radially, indicates that the better performance is obtained when the thrust has a tangential direction.

METEORITIC DUST AND GROUND SIMULATION OF IMPACT ON SPACE VEHICLES. D. H. Robey. Brit. Interpl. Soc. J., Jan.-Feb., 1959, pp. 21-30. 37 refs. Presentation of a general discussion of meteoritic dust and deductions pertaining to the physical properties and probable speeds. It is believed that a large portion of atmospheric dust is generated in the atmosphere by the disintegration and ablation of meteors. Thus, the siliceous and magnetic spherules, which are found on the ground, are believed to originate at meteor altitudes from vaporized meteorites. A large quantity of smaller sized dust is supposed to be cometary, either arriving directly from comets, or indirectly from exploding or disintegrating meteoroids. A proposal for accelerating dust particles to speeds of 10 miles per sec., and possibly up to 18 miles per sec., is presented.

METHODS FOR PREDICTING THE ORBITS OF NEAR EARTH-SATELLITES. D. G. King-Hele and D. M. C. Walker. Brit. Interpl. Soc. J., Jan.-Feb., 1959, pp. 2-14. Description of methods, requiring only simple computation, for predicting the times and positions of the daily transits of a satellite, and the geometry of its orbit. These methods depend upon maintaining an accurate record of the period of revolution, from which the other orbital elements are deduced theoretically. Satellite visibility is discussed. The present methods are shown to be most suitable for satellites with life-times of less than one year.

PERTURBATION OF ELLIPTIC ORBITS BY ATMOSPHERIC CONTACT. II - SOME DEDUCTIONS FROM OBSERVATIONS OF THE ORBITS OF THE FIRST RUSSIAN SATELLITES. T. R. F. Nonweiler. Brit. Interpl. Soc. J., Jan.-Feb., 1959, pp. 14-20. Review of information concerning the action of air resistance on the orbits of 1957 α and 1957 β. The rate of drops of the perigee, the effect of the earth's oblateness, fluctuations in apparent drag, and brightness measurements of celestial objects are considered. It is found that the theoretical results of orbital decay are useful in determining certain features of the satellite, though for prediction purposes proper allowance for Earth oblateness is necessary. There is apparently a considerable daily variation in atmospheric properties within the ionosphere, but mean conditions can be inferred.

THE MOTION OF AN EARTH SATELLITE ON RE-ENTRY TO THE ATMOSPHERE. T. Nonweiler. (9th Internatl. Astron. Congr., Amsterdam, Aug. 25-30, 1958.) Astronautica Acta, Fasc. 1, 1959, pp. 40-62. Solution of the equations of motion of a satellite considering its re-entry into the atmosphere. It is found that the motion is relatively insensitive to the form of orbit which the satellite has been describing beforehand, provided only that it has been described a sufficiently large number of circuits. Likewise it is found that the retardation suffered is practically independent of the size, shape, and weight of the satellite; these factors merely determine at what height the retardation occurs. Some deductions are made concerning the intensity of frictional heating in the descent, and the characteristics of the motion are tabulated.

STRUCTURES

A SIMPLE METHOD OF MATRIC STRUCTURAL ANALYSIS. IV - NONLINEAR PROBLEMS. Bertram Klein. J. Aero/Space Sci., June, 1959, pp. 351-359. Application of a method, developed previously to solve various kinds of nonlinear problems, to those concerning large deflections or buckling, thermal creep, and inelastic stress redistribution involving thermal gradients. The procedure used in each case is one of direct iteration; several numerical examples are worked out.

Cylinders & Shells

THE STABILITY OF A CIRCULAR CYLINDER UNDER FINITE EXTENSION AND TORSION. A. E. Green and A. J. M. Spencer. J. Math. & Phys., Jan., 1959, pp. 316-337. Army-sponsored derivation of relations that exist between the extension, torsion, and dimensions of the cylinder when instability first occurs. The theory is developed for a general elastic material as far as the formulation of the neutral equilibrium equations, but to solve these it is necessary to choose a par-

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ticular form for the strain energy function. A condition for the existence of an adjacent equilibrium position is found in the form of a relation between the roots of a transcendental determinental equation and the dimensions of the cylinder. This equation is solved numerically for a particular value of the extension ratio and for the case in which there is torsion but no extension. Criteria for instability in these cases are presented.

ON THE FOUNDATIONS OF THE THEORY OF THIN ELASTIC SHELLS. M. W. Johnson and E. Reissner. J. Math. & Phys., Jan., 1959, pp. 371-392. ONR-supported derivation of equations for two-dimensional systems of differential equations for stresses and displacements for the circular cylindrical shell of constant thickness under the assumption of small rotationally symmetrical deformations. The circular cylindrical shell is characterized by two lengths, the radius a and the thickness h. By introducing a suitable third axial length in the differential equations of the three-dimensional theory, it becomes possible to expand the solutions of the equations of the three-dimensional theory in terms of powers of a suitable dimensionless parameter. The first terms of these expansions are found to represent the results of conventional shell theory as based on the Euler-Bernoulli hypothesis and on the assumption that h/a is negligibly small compared to unity. The second and higher order terms represent the three effects of (1) finite values of h/a, (2) transverse shear stress deformation, and (3) transverse normal stress deformation.

THE ANALYSIS OF FUSELAGE OF ARBITRARY CROSS-SECTION AND TAPER. I, II. J. H. Argyris and S. Kelsey. Aircraft Eng., Mar.; Apr., 1959, pp. 62-74; 101-112. 57 refs. Presentation of a rational method for the structural analysis of stressed skin fuselages for application in conjunction with the digital computer. The theory is a development of the matrix force method which permits a close integration of the analysis and the programing for a computer operating with a matrix interpretative scheme. A critical review of previous work on fuselage analysis is presented along with a summary of the matrix force method. The equilibrium conditions for the idealized structure are examined, and the relevant equations of equilibrium established in matrix form. The structural geometry covered by the analysis includes most cases encountered in practice and allows for nonconical taper, double-cell cross sections, and doubly connected wings. An attempt has been made to produce a standardized procedure requiring as input information only the simplest geometric and elastic data.

Elasticity & Plasticity

THE GENERALIZED PLANE STRAIN OF AN ELASTO-PLASTIC MATERIAL. D. R. Bland. ZAMP, Mar. 25, 1959, pp. 113-132. 11 refs. Presentation of two methods of solution for certain problems of elasto-plastic materials in generalized plane strain, one being for nonhardening materials, the other for work-hardening. In the former case the characteristics and the equations of stress and velocity were found, and in the latter, the equation satisfied by the stress function. Various simplifying assumptions are made. A tension test of a cylindrical specimen shows that work-hardening distributes the deformation more evenly through the body. The overall effect is that the cross section of the cylinder decreases uniformly along its length until a strain is reached where the increase in work-hardening no longer balances the decrease in area. Solutions for some simple problems are presented.

TWO-DIMENSIONAL PLASTIC FLOW PROBLEMS OF NON-HOMOGENEOUS ANISOTROPIC MEDIA. I - TWO-DIMENSIONAL STATES OF STRAIN. II - TWO-DIMENSIONAL STATES OF STRESS. W. Olszak, P. Perzyna, and C. Szymański. Acad. Pol. Sci. Bul., No. 1, 1959, pp. 7-27. 15 refs. Derivation of equations for two-dimensional problems from the equations of plasticity describing the three-dimensional state in a system of curvilinear orthogonal coordinates. Generalized definitions of two-dimensional and plane states are given in the case of simultaneous existence of anisotropy and nonhomogeneity of the material. Particular cases examined include: monoclinic structure, orthotropy, transverse anisotropy, cubic anisotropy, and isotropy.

Plates

INELASTIC DIFFUSION IN PANELS. M. M. Chen. MIT ASRL TR 76-1 (AFOSR TN 59-33){AD 209205], Nov., 1958. 9 pp. Study of the diffusion problem for the case of nonlinear elasticity in order to determine the redistribution of stresses once the flanges are loaded beyond their proportional limits. The governing differential equation is solved numerically by the Runge-Kutta method for the case where the Ramberg-Osgood exponent, n, is equal to 20. For $n = 2$ the solution is in a closed form. It is shown that a considerable build-up of shear flow appears at the free end for a load slightly greater than the yielding load.

A NOTE ON STRAIN HARDENING CIRCULAR PLATES. W. E. Boyce. J. Mech. & Phys. Solids, Mar., 1959, pp. 114-125. Application of previous solutions for uniformly loaded, simply supported circular plates to partially clamped plates. A piecewise linear theory of plasticity using Prager's hardening law is employed; its more important features are briefly reviewed. The effect of perturbations in the initial yield stress on the post-yield stresses and displacements is also examined.

Plates, Stiffened

LA STABILITA DELL'EQUILIBRIO ELASTICO DI UNA LAMINA RETTANGOLARE IRRIGIDITA LONGITUDINALMENTE SOLLECITATA DA FORZE UNIFORMI DI COMPRESSIONE NELLA

DIREZIONE LONGITUDINALE. Giorgio Bartolozzi. L'Aerotecnica, Dec., 1958, pp. 301-308. In Italian. Investigation of the elastic stability of a longitudinally stiffened flat panel under axial compression. The boundary conditions are established for two cases of instability, and the corresponding equations of stability are obtained. Their solutions are given, both numerically and graphically, for various values of the elastic parameters of the stringers. A comparison with previous experimental results is made and satisfactory agreement is found.

Plates with Holes

THERMAL STRESSES IN A SQUARE PLATE WITH A CENTRAL CIRCULAR HOLE SUBJECTED TO AN ARBITRARY TEMPERATURE GRADIENT. R. D. Sutherland and F. M. White. Convair TM 349-2 (AFOSR TR 59-11) [AD 209850], Feb., 1959. 33 pp. Analysis of the thermal stress problem using the Airy stress functions with the assumption of an arbitrary temperature distribution. The results are applied to a plate subjected to a simple doubly-symmetrical temperature distribution. The hoop stresses are calculated around the perimeter of the perforation and presented as functions of angular displacement for four different inside radii.

Sandwich Construction

DAMPING ENERGY DISSIPATED BY INTERFACES IN BEAM AND PLATE SUPPORTS AND IN SANDWICH CORES. T. J. Mentel. USAF WADC TR 58-547 [AD 206667], Dec., 1958. 25 pp. Comparison of the maximum energy dissipation which can result from viscous and dry friction damping between the longitudinal interfaces at the supports of built-in beams and plates with the total material damping. This type of support damping is shown to be relatively unimportant in the vibration attenuation problem for beams, but may be very important in the case of thin plates. An alternative method for the damping of beams, that of using sandwich construction with an energy dissipating central core, is found to provide an effective damping mechanism in the case where support damping becomes ineffective.

Thermal Stress

THERMOELASTIC WAVES AND THERMAL SHOCK. M. Lessen. J. Mech. & Phys. Solids, Mar., 1959, pp. 77-84. 18 refs. Derivation of the field equations governing the small displacements of a thermoelastic solid and investigation of the properties of plane thermoelastic waves. Thermal shock solutions are developed using the thermoelastic wave solutions, and the problem of thermal shock in an infinite cylinder is considered.

Wings

ELECTRICAL ANALOGUE TO A CELLED TUBE SUBJECTED TO FLEXURE AND TORSION. Melvin Zaid and F. L. Ryder. Aircraft Eng., Apr., 1959, pp. 94-100. Presentation of an approach for the solution to the multi-celled, multi-stringer tube subjected to flexural and torsional loads. The approach is based upon the condition of current continuity and an equivalent to Castigliano's theorem which holds for certain types of electrical networks. The associated equations lend themselves to creating an analog with a high degree of pictorial similarity, so that the network can be constructed without formulating the structural equations. The analog of a simple two-celled structure is devised, and the results obtained by electrical circuit analysis are checked against the structure.

THERMODYNAMICS

Combustion

THE IGNITION OF COMBUSTIBLE MIXTURES BY HOT GASES. H. G. Wolfhard. US, Bur. Mines, Pittsburgh, Squid TR BUM-24-P [AD 147702], Dec., 1957. 27 pp. (Microtext.) Investigation of the minimum condition for fuel-air ignition by relatively large flows of hot gas; the gases being nitrogen, CO_2, and air. Ignition temperature versus mixture composition curves are flat for butane, ethylene, and CO fuels - i.e., the ignition temperature does not change much with mixture composition. The hydrocarbons appear to ignite slightly better on the fuel-rich side, except ethylene, for which the minimum is on the lean side. The minimum propylene corresponds to a stoichiometric mixture; the minimum for butylene is on the fuel-rich side. CO ignites rapidly on the fuel-rich side and CO_2 appears to be as effective as nitrogen for ignition.

TURBULENT FLAME STUDIES IN A TWO-DIMENSIONAL OPEN BURNER. J. H. Grover, E. N. Fales, and A. C. Scurlock. ARS J., Apr., 1959, pp. 275-283. 16 refs. AFOSR-supported investigation of turbulent flames propagating in homogeneous mixtures to determine the location of both the time-average and instantaneous flame fronts, to obtain measurements of the flow in the vicinity of these flame fronts, and to determine accurately the local turbulent flame velocity point-by-point along the mean flame front. From the intercepts of the flow lines and the mean flame front, the local turbulent flame velocity along the flame front is calculated. The turbulent flame velocity increased rapidly with distance above the burner rim. The flame velocity increase can be entirely accounted for by flame wrinkling. Both this result and the appearance of the flash tube photographs, showing the instantaneous flame front, support the wrinkled flame concept of turbulent flame propagation.

Heat Transfer

FURTHER DEVELOPMENTS OF NEW METHODS IN HEAT-FLOW ANALYSIS. M. A. Biot. J. Aero/Space Sci., June, 1959, pp. 367-381. 10 refs. Development of a particular phase of Lagrangian methods in heat-flow problems - i.e., the elimination of "ignorable coordinates." This is accomplished by a special choice of generalized

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coordinates, each of which is constituted by an arbitrary temperature distribution and an "associated flow field." The latter is a vector derived from the corresponding scalar field by a variational method. The use of normal coordinates and their associated flow fields is illustrated by an example. Introduction of Dirac functions and associated flow fields yields a procedure which constitutes a generalization of the classical formulation by Green's functions and integral equations. This is illustrated by application to one-dimensional problems of heating a homogeneous or composite slab and is directly verified by classical methods.

HEAT TRANSFER FROM SURFACES OF NON-UNIFORM TEMPERATURE DISTRIBUTION. I - LAMINAR TRANSFER FROM ISOTHERMAL HEAT POLES ON A FLAT PLATE. Appendix A - DERIVATION OF THE LAMINAR STEP FUNCTION BASED ON QUARTIC PROFILES. Appendix B - HEAT POLES OF UNIFORM HEAT FLUX DENSITY. Appendix C - SOME PROPERTIES OF THE INCOMPLETE BETA FUNCTION. Appendix D - MASS TRANSFER DATA AND RESULTS. Appendix E - PROPERTIES OF NAPHTHALENE. H. H. Sogin. Brown U. Div. Eng. (AFOSR TN 58-930) [AD 205095], Nov., 1958. 81 pp. 20 refs. Application of the Rubesin-Klein-Tribus method to calculate rates of heat transfer by forced convection from two isothermal poles. The general results are applicable to poles of any length in either laminar or turbulent flow. Predictions of laminar transfer are based on Eckert's step function. In an experiment, naphthalene cast in trays is used to simulate the isothermal heat poles while the inert material between them simulates the adiabatic wall. The boundary layer is shown to be laminar. Theoretical and experimental results are found to be in good agreement, confirming the calculation method and Eckert's step function.

HEAT TRANSFER FROM CYLINDERS IN TRANSITION FROM SLIP FLOW TO FREE-MOLECULE FLOW. R. J. Cybulski and L. V. Baldwin. US, NASA Memo. 4-27-59E, May, 1959. 49 pp. 24 refs. Measurement of heat-transfer coefficients for transverse cylinders in air for Mach Numbers from 0.10 to 0.90, Reynolds Numbers from 0.03 to 11.5, and Knudsen Numbers from 0.10 to 5.0 at an air temperature of 80°F. and wire temperatures from 150° to 580°F.

HEAT TRANSFER FROM A HORIZONTAL CYLINDER ROTATING IN OIL. Appendix A - OPERATION WITH WATER. Appendix B - HEAT TRANSFER FROM VERTICAL CYLINDERS. R. A. Seban and H. A. Johnson. US, NASA Memo. 4-22-59W, Apr., 1959. 31 pp. 13 refs. Measurements of the heat transfer for a Prandtl Number range of 130 to 660 and Reynolds Numbers up to 3×10^4. The results show an increasing dependence of free-convection heat transfer on rotation as the Prandtl Number is increased by reducing the oil temperature. At higher rotative speeds the flow becomes turbulent, the free-convection effect vanishes, and the results with oil can be correlated generally with those for air and with mass-transfer results for even higher Prandtl Numbers. For this system, however, the analogy calculations which have successfully related the heat transfer to the friction for pipe flows at high Prandtl Number fail.

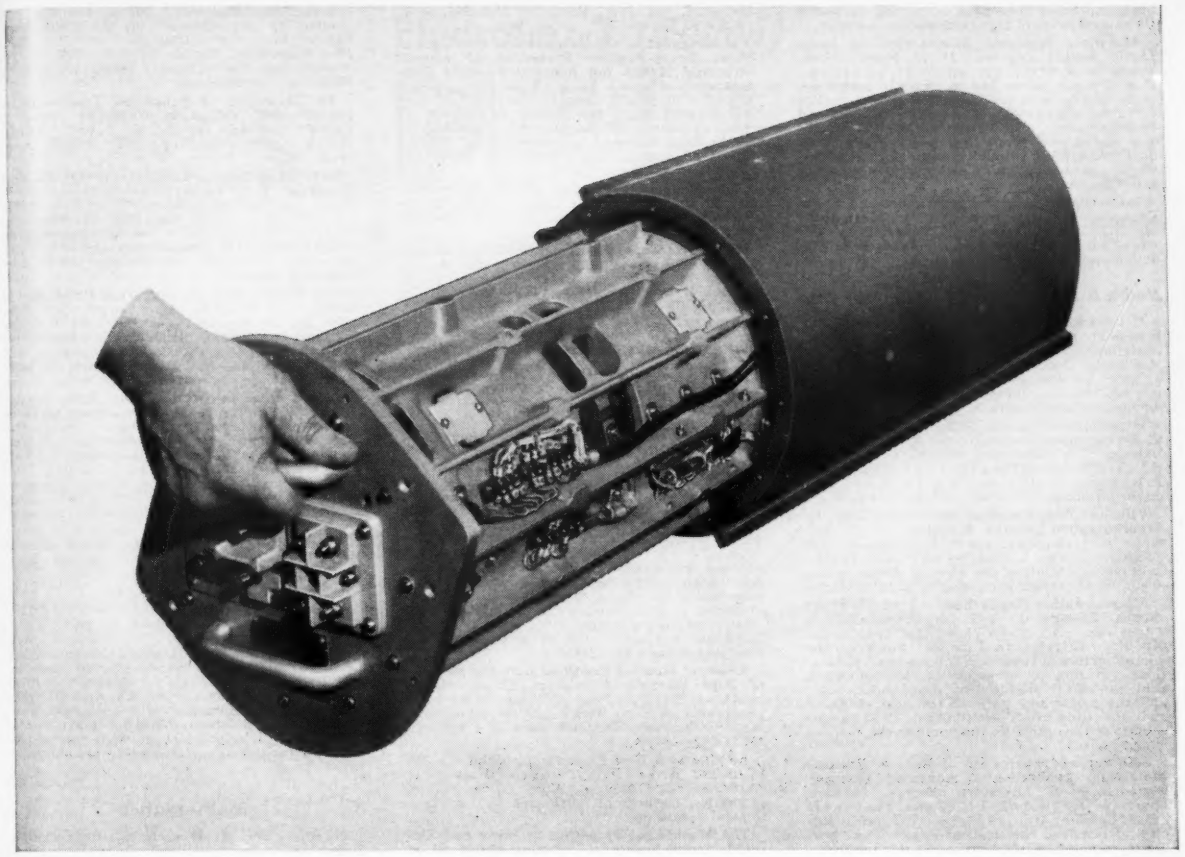
HEAT TRANSFER IN A LIQUID METAL FLOWING TURBULENTLY THROUGH A CHANNEL WITH A STEP FUNCTION BOUNDARY TEMPERATURE. Appendix I - LONGITUDINAL HEAT CONDUCTION. Appendix II - FLUID VELOCITY DISTRIBUTION. Appendix III - EDDY DIFFUSIVITY DISTRIBUTION. Appendix IV - SERIES EXPANSION OF f(r). Appendix V - ASYMPTOTIC CONVECTION SOLUTION. H. F. Poppendiek. US, NASA Memo. 2-5-59W, Mar., 1959. 64 pp. 10 refs. Analytical solution presenting local Nusselt moduli, dimensionless mixed-mean fluid temperatures, and arithmetic-mean Nusselt moduli as functions of Reynolds and Prandtl moduli and a dimensionless axial-distance modulus. These solutions are compared with known solutions of more specific systems as well as with a set of experimental liquid-metal heat-transfer data for a thermal entrance region.

VTOL & STOL

SHROUDED PROPELLER INVESTIGATIONS: AERODYNAMIC CHARACTERISTICS OF A SHROUD WITH CENTERBODY. V. O. Hoehne. U. Wichita, Dept. Eng. Res. Rep. 337, Feb., 1959. 45 pp. Study made in order to determine the effect of shroud diffusion, hub size, Reynolds Number, shroud shape, and aspect ratio on the lift, drag, and pitching moment characteristics of a shroud with centerbody. Results show that diffusing the after portion of the shroud increases the lift curve slope and maximum lift coefficient, reduces the angle of attack for stall, and moves the center of pressure forward. Increasing the centerbody or hub size relative to the shroud diameter has little effect on the lift characteristics of the unit, but increases the minimum drag coefficient with a nondiffused shroud. The combined effects of hub size and diffusion, however, cause minimum drag to decrease with an increase in hub size.

WATER-BASED AIRCRAFT

A GENERALIZED HYDRODYNAMIC-IMPACT THEORY FOR THE LOADS AND MOTIONS OF DEEPLY IMMERSED PRISMATIC BODIES. M. F. Markey. US, NASA Memo. 2-10-59L, Mar., 1959. 27 pp. Derivation and application of a theory to immersed prismatic bodies. The equations of motion are generalized by using a mean value of the aspect-ratio correction and by assuming a variation of the two-dimensional water mass for the deeply immersed body. Comparison of experiment with theory is shown at maximum load and maximum penetration for the flat-bottom model with beam-loading coefficients from 36.5 to 133.7 over a wide range of initial conditions. A dead-rise angle correction is applied, and maximum-load data are compared with theory for the case of a model with 30° dead-rise angle and beam-loading coefficients from 208 to 530.



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heat, and linear coefficient of thermal expansion for several types of high-temperature materials.

Materials Problems Encountered in Large Liquid Rocket Engines. D. E. Roda. *Aero. Procurement*, Mar., 1959, pp. 15–17, 33. Discussion of particular design problems in rocket engines emphasizing the material aspects. The operation of an engine is first described, followed by a discussion on such problems as low-temperature mechanical properties, gear teeth fatigue, quality control of aluminum castings, and compatibility of metals and plastics with chemically active liquids.

Materials for Long Range Missiles and Space Vehicles. W. A. Mrazek. *SPE J.*, Mar., 1959, pp. 211–213. Discussion of material requirements due to advancing developments in missile design and of some problem areas.

Metals & Alloys

O Poverkhnostnoi Aktivnosti Zhidkikh Metallicheskikh Pokrytii i ikh Vliianii na Prochnost' Metallov. N. V. Pertsov and P. A. Rebinder. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 1,068–1,070. 11 refs. In Russian. Determination of the surface activity of liquid metal coatings and their influence on the strength of metals.

Issledovanie Vliianiia Nekotorykh Ingibitorov na Korrozionnoe Rastreskivanie Metallov. S. A. Balezin, V. V. Romanov, and N. I. Podobaev. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 902–905. In Russian. Study of the effect of some inhibitors on the formation of corrosive cracks in metals.

Vliianie Poverkhnostno-Aktivnykh Sred na Poverkhnostnyi Naklep Metallov. G. I. Epifanov, N. I. Glagolev, and P. A. Rebinder. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 663–666. 11 refs. In Russian. Study of the effect of surface active media on the strain hardening of metal surfaces.

Mikrostruktura Napriazhenii v Liniiakh Skol'zheniia i Dislokatsii. V. L. Indenbom and G. E. Tomilovski. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 673–676. 12 refs. In Russian. Study of the microstructure of stresses in slip lines and dislocations, covering the structure of the dislocation field, the effects produced by single dislocations, and the conformity between the field structure and the dislocation distribution. The applicability of the optical method used in the analysis is emphasized.

Selection and Evaluation of Rare or Unusual Metals for Application to Advanced Weapons Systems. I—A Literature Survey. Bernard Love. *USAF WADC TR 57-666, Pt. I [AD 155685]*, June, 1958. 174 pp. 767 refs. Review of physical, chemical, and mechanical properties of hafnium, rhodium, and ruthenium.

Effect of Residual Stress on Brittle Fracture. Hiroshi Kihara and Koichi Masubuchi. *Welding J. Res. Suppl.*, Apr., 1959, pp. 159-s–168-s. 10 refs. Presentation of results of experimental studies on the brittle fracture of weld structures at low stress level. The stress necessary to initiate and propagate brittle fracture, and the effect of preloading at high temperature on the behavior of a joint, are investigated.

Research on Liquid Metals as Power Transmission Fluids. R. H. Blackmer. *USAF WADC TR 57-294 [AD 151001]*, Feb., 1958. 93 pp. 29 refs. Study of eutectic alloys of sodium and potassium for possible hydraulic system applications at temperatures from 10°F. to 1,000° F.

O Mekhanizme Razvitiia Zarodyshevykh Treshchin v Kristallakh pri ikh Plasticheskom Deformirovanii. V. N. Rozhanskii. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 648–651. 18 refs. In Russian. Discussion covering the mechanism of microcrack formation in crystals subjected to plastic deformation, including a survey of previous research.

Internal-Stress Distribution of Single Spot Welds in Relation to Their Fatigue Life. G. Welter and A. Choquet. *Welding J. Res. Suppl.*, Apr., 1959, pp. 145-s–158-s. 11 refs. Development of test methods for measuring residual strains and comparison of results obtained. The improvement of the fatigue resistance of spot welds by a specific hydrodynamic treatment is shown.

High-Temperature Alloys. Michel Urbain. *Cobalt*, Dec., 1958, pp. 13–32. 32 refs. Discussion of applications, composition, and properties of high-temperature alloys used in aircraft and missiles.

Relation Between Strength and Creep of Metals and Alloys. S. N. Zhurkov and T. P. Sanfirova. *Sov. Phys. - Tech. Phys.*, Aug., 1958, pp. 1,586—1,592. Translation. Analysis of the steady or quasi-ductile stage of creep during which the rate of deformation is almost constant. From experimental data obtained it is possible to determine the temperature dependence of the quasi-ductile flow and the time to practice and to calculate the activation energy of these processes.

A Selection Guide to Heat-Resistant Cast High Alloys. E. A. Schoefer. *Mach. Des.*, Apr. 2, 1959, pp. 118–125. Discussion of the determinant selection factors: corrosion resistance, strength, physical properties, and design requirements.

The Mechanical Properties at Room and Elevated Temperatures of K-Monel Sheet. D. C. Hayward. *Gt. Brit., RAE TN Met. 301*, Sept., 1958. 14 pp.

Investigation of the Compressive, Bearing, and Shear Creep-Rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures. IV, V. L. A. Yerkovich. *USAF WADC TR 54-270, Pts. IV, V [AD 155570; AD 206661]*, May; Dec., 1958. 96; 84 pp. 12 refs. Presentation in tabular and graphical form of the high-temperature properties of PH15-7 Mo stainless steel, 6Al-4V titanium alloy, and 2024-T3 aluminum.

The Magnetic Properties and the Microstructure of High-C, High-Cr Magnet Steel. Kyōji Tachikawa. *Tokyo U. Aero. Res. Inst. Rep. 336*, Sept., 1958. 17 pp.

On the Hardness Change in Mild Steels Due to Reversed Stresses and the Plastic Region Around Tip of Fatigue Crack. Tsunemi Uryu. *Kyushu U. Rep. Res. Inst. Appl. Mech.*, No. 22, 1958, pp. 49–62.

Metals & Alloys, Nonferrous

Tensile Properties of Molybdenum and Tungsten from 2500° to 3700°F. R. W. Hall and P. F. Sikora. *U.S., NASA Memo. 3-9-59E*, Feb., 1959. 30 pp.

The Mechanical Properties of Specimens Cut from a 5 Inch Diameter Bar of Aluminium Alloy to DTD. 683. N. J. F. Gunn. *Gt. Brit., RAE TN Met. 292*, Aug., 1958. 32 pp.

Low-Cycle Fatigue of Notched and Unnotched Specimens of 2024 Aluminum Alloy Under Axial Loading. T. H. H. Pian and Richard D'Amato. *USAF WADC TN 58-27 [AD 142307]*, Feb., 1958. 77 pp. 24 refs. Test results for the notched specimens showing that a straight line relationship existed between the range of strain measured at the edge of the notch and the number of cycles to failure when these variables were plotted on log-log scales. This straight line relationship was also found to describe the unnotched specimen test data.

Residual Stresses Resulting from the Forming of High Strength Aluminium Alloys. G. A. Hawkes. *RAeS J.*, Feb., 1959, pp. 90–94. Application of an X-ray back reflection technique to measure the surface residual stress of DTD 683, DTD 687, and B.S.S. L65.

Beryllium, A New Engineering Metal. J. W. F. Blizard, Jr., and F. A. Twitchell. *Materials in Des. Eng.*, Mar., 1959, pp. 91–93. Discussion of properties, methods of fabrication, and applications of beryllium.

The Mechanical Properties at Room and Elevated Temperatures of Titanium Alloy Sheet M.S.T.-6Al-4V. D. C. Hayward. *Gt. Brit., RAE TN Met. 270*, Sept., 1958. 15 pp.

The Mechanical Properties at Room and Elevated Temperatures of Titanium Alloy Sheet A110AT. D. C. Hayward. *Gt. Brit., RAE TN Met. 284*, Sept., 1958. 15 pp.

The Mechanical Properties at High Rates of Heating and Loading of Commercially Pure Titanium Ti 75A at Temperatures up to 700°C. M. S. Binning and B. Angell. *Gt. Brit., RAE TN Met. 294*, July, 1958. 14 pp.

Le Titane et ses Alliages en Construction Aéronautique. Pierre Vachet. *Tech. & Sci. Aéronautiques*, Oct., 1958, pp. 221–241. 29 refs. In French. Comprehensive review of titanium and its alloys in aeronautical construction, including data on equilibrium and stabilization, strength, annealing, welding, and heat treating.

Effect of Prior Creep on Mechanical Properties of Aircraft Structural Metals. III—C110M Titanium Alloy. Appendix—Statistical Investigation of Test Data. J. V. Cluck, H. R. Voorhees, and J. W. Freeman. *USAF WADC TR 57-150, Pt. III [AD 155578]*, May, 1958. 88 pp.

An Investigation of the Effects of Impurities and Metallurgical Variables on the Notch Sensitivity of Titanium Alloys. F. C. Holden, R. W. Douglass, H. R. Ogden, and R. I. Jaffee. *USAF WADC TR 58-438 [AD 207078]*, Dec., 1958. 79 pp.

Nonmetallic Materials

Non-Metallics for Rocket Components. S. P. Kaprielyan. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 7–9. Discussion on the use of inorganic silicates with organic binders as insulation materials. Manufacturing methods and applications of nonmetallic materials are considered.

Some Thermal Properties of Durestos Type Materials. P. H. H. Bishop and K. F. Rogers. *Gt. Brit., RAE TN Chem.1333*, Aug., 1958. 33 pp. 11 refs.

The Tensile Fatigue Properties of Vacuum Moulded "Durestos." D. J. McCue. *Gt. Brit., RAE TN Chem.1334*, Aug., 1958. 9 pp.

A Study of the Behaviour of Some Elastomeric and Plastomeric Materials for Packings. E. Cianetti. *(Min. Dif. Publ.*, No. 23, 1956.) *Gt. Brit., MOS TIL/T4937*, Oct., 1958. 26 pp. Translation.

Notes on the International High Polymer Conference, Nottingham, July 21st-24th, 1958. N. J. L. Megson and E. W. Russell. *Gt. Brit., RAE TN Chem. 1336*, Sept., 1958. 9 pp.

Konstruktionshandbuch für Klebestoffe. H. Winter, H. Schlothauer, and H. Meckelburg. (*Mach. Des.*, Apr., 1954, pp. 144–174.) *DFL Inst. Flugzeugbau Bericht No. 105*, 1958. 86 pp. Translation. In German. Presentation of a design manual on adhesives.

An Evaluation of Fungicidal Treatments in Cotton Cargo Parachute Webbings Stored at College, Alaska. II. E. F. Little. *USAF WADC TR 56-384, Pt. II [AD 155857]*, Aug., 1958. 50 pp.

Fabricating Silicone Laminates to Get the Most Strength. L. W. Breed, Howard Christie, Calvin Bolze, and Fred Baiocchi. *SPE J.*, Mar., 1959, pp. 220–224. USAF-supported experimental study of the importance of laminating parameters in determining the ultimate strength of silicone-glass fabric laminates. Results were analyzed by statistical methods.

Les Résines Phénoliques Basse Pression. S. Kohn. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 39–46. In French. Survey covering the basic properties of phenolic resins, fabrication methods, and effect of certain parameters, as well as advantages and limitations of resins for high-temperature applications.

Investigation of Condensation Type Elastomers. IV. Appendix—**Fluorine Containing Monomers for Condensation Polymers.** E. T. McBee, G. C. Schweiker, B. S. Marks, C. J. Verbanic, B. L. Lucas, and E. V. Gouinlock. *USAF WADC TR 55-221, Pt. IV [AD 151009]*, Feb., 1958. 72 pp. 33 refs. Description of the preparation, compounding, cross-linking, and properties of certain fluorine-containing polyester elastomers.

Thermal Conductivity of Clear Fused Silica at High Temperatures. K. L. Wray and T. J. Connolly. *Avco Res. Lab. RR 44*, Feb., 1959. 13 pp.

Testing Methods

Early Detection of Fatigue in Aluminum Alloys by Ultrasonics. Karl Sittel, Marvin Herman, and R. C. Good, Jr. *USAF WADC TR 58-35 [AD 155558]*, May, 1958. 45 pp. 87 refs. Survey of the literature covering ultrasonic wave propagation and fatigue-induced damage in aluminum, and description of an experimental program for early fatigue detection in aluminum alloys.

Mathematics

Formulae for Hyperosculatory Interpolation, Direct and Inverse. H. E. Salzer. *Quart. J. Mech. & Appl. Math.*, Feb., 1959, pp. 100–110. 11 refs. Presentation of a convenient and concise scheme for direct and inverse hyperosculatory interpolation for a real function $f(x)$ tabulated at equal intervals, with its first and second derivatives either explicitly tabulated or readily available.

On Castelnuovo's Criterion of Rationality $p_a = P_2 = 0$ of an Algebraic Surface. Oscar Zariski. *Ill. J. Math.*, Sept., 1958. 13 pp. Reprint. AFOSR-supported study.

Twin Convergence Regions for Continued Fractions $1 + K(a_n/1)$ one of Which is the Circular Region $|a_{2n-1}| \leqq \rho^2$. W. J. Thron. *U. Col. Rep.*, 1958. 61 pp. USAF-supported research.

Applications of the Theory of Morse to Symmetric Spaces. Raoul Bott and Hans Samelson. *U. Mich. Paper (AFOSR TN 59-130) [AD 210769]*, Mar., 1959. 70 pp. 20 refs. Reprint.

Reshenie Nekotorykh Binarnykh Additivnykh Zadach Podschetom Dispersii v Progressiakh. Iu. V. Linnik. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 975–977. In Russian. Derivation of a solution for certain binary additive problems by means of computing the dispersion in progressions.

O Vtoroi Smeshannoi Proizvodnoi. B. S. Mitiagin. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 606–609. In Russian. Derivation of a solution for the problem of second mixed derivative.

O Sinteze Skhem s Pomoshch'iu Lineinykh Preobrazovanii Peremennykh. E. I. Nechiporuk. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 610–612. In Russian. Analysis covering the scheme synthesis using linear transformations of variables.

Asimptotika Reshenii Nekotorykh Kraevykh Zadach dlia Kvazilineinykh Uravnenii s Malym Parametrom pri Starshei Proizvodnoi. A.B. Vasil'eva. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 583–586. In Russian. Study of the asymptotic behavior of certain boundary problems for quasi-linear equations involving a small parameter in the highest derivative term.

Ob Ustoichivosti Reshenii Zadachi Koshi i Smeshannoi Zadachi dlia Giperbolicheskikh Uravnenii. A. Kh. Gelig. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 591–594. In Russian. Determination of the stability of solutions for the Cauchy problem and the mixed problem of hyperbolic equations.

Extensions, Retractions and Projections. B. Grünbaum. *Hebrew U. Dept. Math. TN 2 (AFOSR TN 58-210) [AD 154111]*, Jan., 1958. 64 pp. 54 refs. Development of an intermediate theory dealing with metric spaces and with

operations restricted by conditions analogous to the boundaries of the norm of linear transformations. The results of Aronszajn-Panitchpakdi are generalized to establish the connection between uniform retractions and extensions of uniformly continuous functions with a subadditive modulus of continuity.

On the Construction of Periodic Maps Without Fixed Points. P. E. Conner and E. E. Floyd. *Va. U. Dept. Math. TN 9 (AFOSR TN 59-81) [AD 210141]*, Oct., 1958. 14 pp.

O Zavisimosti Mezhdu Chislom Peremen Znaka Resheniia Parabolicheskogo Uravneniia i Rostom Resheniia. E. M. Landis. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 787–790. In Russian. Determination of the relationship between the growth of the solution for a parabolic equation and the number of its sign variations.

On Tensor Products of n-Plane Bundles. Emery Thomas. *U. Calif. Dept. Math. TR 8 (AFOSR TN 58-1022) [AD 206362]*, Nov., 1958. 52 pp.

Nekotorye Voprosy Vychisleniia Mnogochlenov. E. G. Belaga. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 775–777. In Russian. Analysis of certain problems involved in the calculation of polynomials.

Analiticheskaia Emkost' Mnozhestv i Nekotorye ee Svoistva. A. G. Vitushkin. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 778–781. In Russian. Formulation of preliminary assumptions on the analytic capacity of sets and some of its properties.

Nekotorye Funktsional'nye Neravenstva Tipa Teorem Vlozheniia. V. P. Il'in. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 967–970. In Russian. Analysis of certain functional inequalities of the imbedding theorem type.

Izometrichnoe Vlozhenie Poliedrov. V. A. Zalgaller. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 599–601. In Russian. Presentation of an approach to isometric imbedding of polyhedra.

K Voprosu ob Osesimmetrichnykh Dvizheniiakh Zhidkosti. D. Dumitresku. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 963–966. In Russian. Development of two mathematical approaches to the solution of the problem covering the axisymmetric motion of liquids around bodies. One of the methods uses Bessel polynomials and the other involves finite differences.

O Resheniiakh Nekotorykh Vozmushchennykh Sistem v Okrestnosti Periodicheskikh Dvizhenii. V. M. Volosov. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 587–590. 11 refs. In Russian. Derivation of solutions for certain perturbed systems in the neighborhood of periodic motions.

O Zavisimosti Mezhdu Chislom Peremen Znaka Resheniia Ellipticheskogo Uravneniia i Rostom Resheniia. E. M. Landis. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 602–605. In Russian. Determination of the relationship between the growth of the solution for an elliptical equation and the number of its sign alterations.

Otsenki v L_p Reshenii Ellipticheskikh Sistem. L. N. Slobodetskii. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 616–619. In Russian. Generalization of a set of previously obtained results on the estimate in L_p of solutions for elliptical systems.

Fixed Points and Other Special Points and Point Sets Under Mapping. D. G. Bourgin. *U. Ill. Rep. (AFOSR TR 58-146) [AD 205093]*, Jan. 5, 1959. 49 pp. 23 refs.

Limit Theorems for the Distributions of the Maxima of Partial Sums of Independent Random Variables. E. G. Kimme. *Ore. State Coll. Dept. Math. TR 1 (AFOSR TN 58-720) [AD 162255]*, Sept. 1, 1957. 95 pp.

On the Evaluation of Certain Finite Sums of Progressive Products. A. R. Collar. *RAeS J.*, Feb., 1959, pp. 118, 119.

Research in the Area of Mathematical Analysis. *Hebrew U. Dept. Math. TFR (AFOSR TR 58-111) [AD 210471]*, Dec., 1958. 33 pp.

Auxiliary Integrals for Lattice Sums. A. A. Maradudin and G. H. Weiss. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-156 (AFOSR TN 59-55) [AD 209426]*, Dec., 1958. 11 pp.

The Theory of Characteristic Classes. John Milnor. *Princeton U. Rep. (AFOSR TN 59-9) [AD 208281]*, 1959. 144 pp. 29 refs. Study of the cohomology of n-dimensional vector space bundles.

Homomorphisms of Certain Algebras of Measures. Irving Glicksberg. *Stanford U. Appl. Math. & Statistics Lab. TN 2 (AFOSR TN 58-1042) [AD 206572]*, Dec. 31, 1958. 27 pp. Analysis to determine all norm-decreasing homomorphisms of certain algebras of measures (similar to L_1) on compact group G into the algebra of measures on compact group H.

The Structure of Semi-Simple Lie Algebras. Melvin Hausner and Shlomo Sternberg. *RIAS TR 58-9 (AFOSR TN 58-862) [AD 203673]*, 1958. 62 pp.

The Maximal Ideals of Certain Function Algebras. Richard Arens. *Pacific J. Math.*, Winter, 1958, pp. 641–648.

Centralizers in Jordan Algebras. Bruno Harris. *Pacific J. Math.*, Winter, 1958, pp. 757–790. 17 refs. Analysis aiming to prove for Jordan algebras some theorems on centralizers of subalgebras analogous to known results in the theory of associative algebras.

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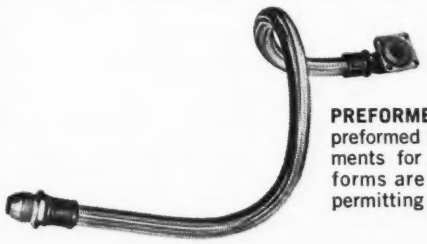

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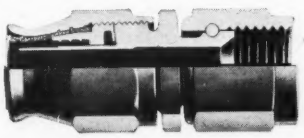

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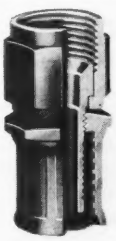

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O Nekotorykh Beskonechnykh Sistemakh Lineinykh Algebraicheskikh Uravnenii, Razreshaemykh v Zamknutoi Forme. I. Kh. Khairullin. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 795–798. 11 refs. In Russian. Analysis covering some infinite systems of linear algebraic equations requiring a closed-form solution.

The Principle Three-Dimensional Subgroup and the Betti Numbers of a Complex Simple Lie Group. Bertram Kostant. *U. Calif. Dept. Math. TR 9 (AFOSR TN 58-1084) [AD 207581]*, Dec., 1958. 98 pp. 14 refs.

Automorphic Group Representations. R. J. Blattner. *Pacific J. Math.*, Winter, 1958, pp. 665–677. 10 refs. Investigation to determine the conditions on the group, representation, and ring which guarantee the production of outer automorphisms of the ring.

Equivalence and Perpendicularity of Gaussian Processes. Jacob Feldman. *Pacific J. Math.*, Winter, 1958, pp. 699–708. Analysis showing that the equivalence or perpendicularity dichotomy holds in general for pairs of measures induced by Gaussian stochastic processes. Segal's necessary and sufficient conditions for equivalence are extended to cover the case of nonzero mean.

On the Theory of (m, n)-Compact Topological Spaces. I. S. Gál. *Pacific J. Math.*, Winter, 1958, pp. 721–734. 17 refs.

O Nerazreshimosti Nekotorykh Problem Topologii. A. Markov. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 978–980. In Russian. Extension of previously derived results on the insolubility of certain problems of topology.

Osnovy Obobshchennogo Differentsial'no-Integral'nogo Ischisleniia. A. V. Svetlanov. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 981–983. 10 refs. In Russian. Definition of the principles of generalized differential integral calculus.

Metod Malogo Parametra dlia Operatornykh Uravnenii. A. E. Gel'man. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 782–784. In Russian. Presentation of the small parameter method for operator equations. The results of the calculation are applicable to problems of stability of solution and to nonlinear problems of mathematical physics.

Asymptotic Theory of Second Order Differential Equations with Two Simple Turning Points. N. D. Kazarinoff. *Arch. Rational Mech. & Anal.*, No. 2, 1958, pp. 129–150. Reprint. AFOSR-supported study.

Teorema Sushchestvovaniia i Edinstvennosti Resheniia Kraevoi Zadachi dlia Sistemy Obyknovennykh Differentsial'nykh Uravnenii. A. P. Plekhotin. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 613–615. In Russian. Derivation of a theorem on the existence and uniqueness of solution of the boundary problem for a system of ordinary differential equations.

O Differentsial'nykh Uravneniiakh Pervogo Poriadka v Gil'bertovom Prostranstve s Peremennym Polozhitel'no-Opredelennym Samosopriazhennym Operatorom, Drobnaia Stepen' Kotorogo Imeet Postoiannuiu Oblast' Opredeleniia. P. E. Sobolevskii. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 984–987. 16 refs. In Russian. Derivation of first-order differential equations in a Hilbert space with a variable, positively defined self-adjoined operator whose fractional power has a constant definition domain.

Cesàro Partial Sums of Harmonic Series Expansions. M. S. Robertson. *Pacific J. Math.*, Winter, 1958, pp. 829–846.

Korrektnaia Granichnaia Zadacha dlia Nekotorykh Neklassicheskikh Operatorov. A. A. Dezin. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 595–598. In Russian. Formulation of the boundary problem for certain nonclassical operators.

Approximation of Semi-Groups of Operators. H. F. Trotter. *Pacific J. Math.*, Winter, 1958, pp. 887–919. 22 refs. Introduction of the notion of an approximating sequence of Banach spaces and definition of associated concepts of convergence of vectors and operators. Adjoint spaces of an approximating sequence, the convergence problem proper, and the convergence of random walks to one-dimensional diffusion processes are considered.

Nekotorye Teoremy o Vozmozhnosti Ravnomernogo Priblizheniia Nepreryvnykh Funkstii Analiticheskimi Funktsiiami. A. G. Vitushkin. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 959–962. In Russian. Establishment of some theorems on the possibility of a uniform approximation of continuous functions by analytic functions.

Drobnye Stepeni Samosopriazhennykh Rasshirenii Operatorov i Nekotorye Granichnye Zadachi. O. M. Kozlov. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 971–974. In Russian. Analysis covering fractional powers of self-adjoined extensions of operators and some boundary problems.

Regularity Preserving Factor Sequence Transformations of Series of Characteristic Functions of the Differential Operator $z^N - d^2/dz^2$. W. J. Klimczak. *Trinity Coll. Rep. (AFOSR TN 58-1059) [AD 206990]*, Nov. 30, 1958. 24 pp.

An Operator Identity. Clen Baxter. *Pacific J. Math.*, Winter, 1958, pp. 649–663. USAF-supported generalization of Spitzer's functional identity involving operators. The application of more or less analytical methods shows that the use of combinatorial methods can be avoided.

Topology and the Solution of Linear Systems. R. B. Ash. *Columbia U. Sch. Eng. Dept. Elec. Eng. TR T-31/B (AFOSR TN 58-726) [AD 162261]*, June 15, 1958. 18 pp. Application of linear graph theory to the study of feedback systems. Two topological matrices, called the exit and entrance matrices, are defined and the transmission matrix of the system is expressed in terms of these matrices.

Mechanics

On Longitudinal Impact. I—Fundamental Cases of One-Dimensional Elastic Impact; Theories and Experiments. H. C. Fischer. *Appl. Sci. Res., Sect. A*, No. 2-3, 1959, pp. 105–139. 37 refs. Review of known analytical, graphical, and numerical methods for one-dimensional treatment of longitudinal impact and application of the "graphodynamical" method to some fundamental cases. A comparison of the various theories is made.

Meteorology

Differential Advection as a Factor in Clear-Air Turbulence. E. L. Keitz. *J. Meteorology*, Feb., 1959, pp. 57–62. 14 refs. USAF-supported correlation of clear-air turbulence observations made by accelerometer measurements with 6-hour forecasts of the change in vertical stability.

Application of Numerical Methods to Extended Forecasting Practices in the U.S. Weather Bureau. Jerome Namias. *Mo. Weather Rev.*, Dec., 1958, pp. 467–476. Description of new procedures for applying numerical methods to extended forecasting, covering some of their advantages.

A Preliminary Evaluation of Suttons Hypothesis for Diffusion from a Continuous Point Source. M. L. Barad and D. A. Haugen. *J. Meteorology*, Feb., 1959, pp. 12–20.

Atmospheric Structure & Physics

On the Numerical Integration of the Primitive Equations of Motion for Baroclinic Flow in a Closed Region. J. Smagorinsky. *Mo. Weather Rev.*, Dec., 1958, pp. 457–466. Development of a system of integration for initial conditions corresponding to the wind vector, the specific volume, and the vorticity of the vertically integrated flow. Methods for reducing truncation error and for increasing the rate of convergence of the elliptic part are discussed.

Cosmic-Ray Produced Radioactive Isotopes as Tracers for Studying Large-Scale Atmospheric Circulation. B. Peters. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 351–370. 26 refs.

Military Aviation, Ordnance

Special Issue: Strategic Mobility; Low-Level Bombing. *Interavia*, Mar., 1959, pp. 240–254, 265–270, 279–283. *Partial Contents*: Mobility in Global War, P. M. Gallois. The Changing Role of the Aircraft Manufacturer in the Missile Age. No Luke-Warm War with a Strong Air Defense, A. T. King. Low-Altitude Nuclear Strike, K. A. Leppard. The New Generation of British Low-Level Strike Aircraft, D. H. Wood. Long-Range Fighters and Air-to-Air Missiles for Area Defense. Is There an Answer to the Low-Flying Bomber? S. C. Dunn. Missiles and Aircraft is Sweden's Answer.

Britain's Fleet Air Arm Today and Tomorrow. *The Aeroplane*, Mar. 20, 1959, pp. 346, 347. Discussion of the various roles of the aircraft carriers and of how the aircraft carry out their tasks.

Improving the Capability. *The Aeroplane*, Mar. 20, 1959, pp. 334, 341–343. Survey of the operational capability of the RAF based on equipment requirements and recent developments.

Safing, Arming, and Fuzing Concepts. D. E. Coles. *Missile Des. & Devel.*, Mar., 1959, pp. 20–23. Presentation of a conceptual analysis of various individual components which could provide safing, arming, fuzing, and self-destruction.

Missiles, Rockets

Vanguard Testing: Backbone of Present Ballistic Missile Art. W. E. Howard. *Missiles & Rockets*, Apr. 6, 1959, pp. 20, 21.

La Fusée Lunaire Expérimentale à Satellite: Pioneer I. *Fusées*, No. 3, 1958, pp. 119–122. In French. Discussion of the satellite carrying rocket Pioneer I, covering general characteristics of the rocket, basic principles of space flight, and some details of the measuring devices.

Nouvelle Construction Légère de la Cellule des Fusées Téléguidées Oerlikon de Défense Antiaérienne. F. B. Stencel. *Fusées*, No. 3, 1958, pp. 143–151. In French. Presentation of data on the light construction of fuselage sections for the Oerlikon antiaircraft guided missile.

Motion Units to Simplify Space Travel Computations. Bemrose Boyd. *ARS J.*, Mar., 1959, p. 216.

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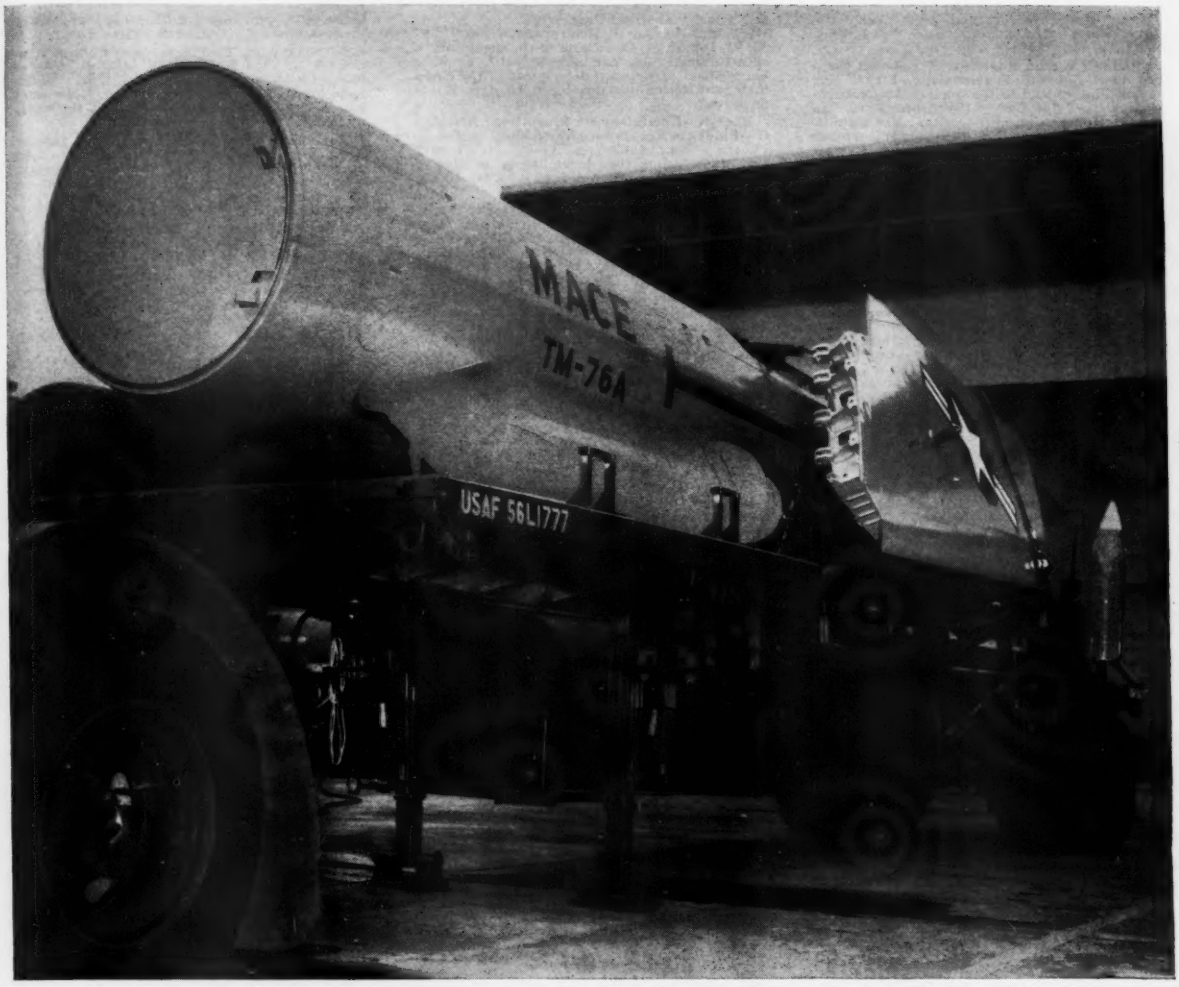

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What We Have Learned from Vanguard. Milton Rosen. *Astronautics*, Apr., Pt. I, 1959, pp. 28, 29, 110, 111.

Stabilisation d'un Engin par Evasement Conique du Culot en Supersonique Elevé. Ph. Poisson-Quinton and R. Cérésuela. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 7, 8. In French. Description of a technique for stabilizing bodies of revolution at hypersonic speeds by means of a conical flare at the throat.

Design for Space-Vehicle Control System Reliability. R. O. Anderson. *USAF WADC TN 58-156* [*AD 155612*], Apr., 1958. 18 pp. Presentation of the results of a reliability investigation of several manned and unmanned space-vehicle attitude control systems. In addition, several promising design methods are analyzed to determine the benefits from reliable system designs.

An Attitude Control System for Space Vehicles. Walter Haeussermann. (*ARS Semi-Annual Meeting, Los Angeles, June 9–12, 1958.*) *ARS J.*, Mar., 1959, pp. 203–207. Presentation of an attitude control system using expulsion charges to compensate for initial disturbances. Control system characteristics and attitude sensing are described.

Simplified Tracking Gear Provides Much Data. D. E. Pierce. *Missiles & Rockets*, Mar. 16, 1959, pp. 29, 30, 33. Description of a private tracking station using the interferometer principle and a two-channel oscillograph to record data.

Flight Testing Spacecraft. Roger Schock and R. F. Lander. *Electronics*, Mar. 27, 1959, pp. 53–57. Description of the High Range, an amalgam of flight- and missile-test ranges for checking out the X-15 research vehicle. Radar tracking, telemetering, and data-recording are considered.

Load Cells Measure Atlas Weight and Thrust to 50 lb. R. J. Carleton, Jr. *Space/Aeronautics*, Apr., 1959, pp. 115, 118. Description of load cells for measuring and recording empty and fueled weight, and to resolve thrust force components during firing tests.

Designing a Jet Deflector for the Hawk Launcher. J. A. Quinville. *Space/Aeronautics*, Apr., 1959, pp. 65, 66, 71–78 (ff.). Development of a diffuser-type deflector designed to prevent soil erosion from jet blast around the Hawk launch position. The scale model test facility is described and results are given for solid deflectors, deflectors with circular holes, and slotted deflectors.

Propulsion for Moon-Landing Maneuvers. Saxe Dobrin. *Missile Des. & Devel.*, Mar., 1959, pp. 24, 25. Discussion of thrust requirements for moon landing. Sample calculations are presented.

Navigation

Inertial Navigation. J. E. Pateman. *RAeS J.*, Feb., 1959, pp. 113–117. Description of the inertial navigation system and of its advantages over other systems. The testing of precision components is discussed.

The Earth and Inertial Space. II—Shape of the Earth. R. H. Parvin. *Aero/Space Engrg.*, May, 1959, pp. 33–36. 11 refs. Discussion of the shape of the earth and its effect on inertial navigation parameters.

Traffic Control

Air Traffic Control and Its Influence on the Navigation Problem. D. O. Fraser. *RAeS J.*, Mar., 1959, pp. 175–179. Presentation of a brief outline of the ATC problem. The need for planning, as well as the separations used by the air traffic control and their possible reduction are discussed along with alternatives to ground control.

Nachrichtenaustausch und Automation in der Flugsicherung. Kurt Heidelauf. *ZfW*, Feb., 1959, pp. 45–52. 12 refs. In German. Outline of the purpose, scope, and techniques of the aeronautical fixed and mobile information exchange services. Means for the automation of the technical aids serving the aeronautical telecommunication service and the air traffic control service are discussed in terms of their development.

Nuclear Energy

NASA Reactor Facility Hazards Summary. *U.S., NASA Memo. 12-8-58E, vol. I*, Jan., 1959. 384 pp. 101 refs. Description of a proposed reactor facility, the characteristics of the site, and the hazards of operation at this location. The vortex is designed to make pumped loop studies of aircraft reactor fuel elements, shielding studies, and nuclear and solid state physics experiments.

NASA Reactor Facility Hazards Summary. *U.S., NASA Memo. 12-10-58E, vol. II*, Feb., 1959. 194 pp. 26 refs. Description of a proposed reactor facility, the characteristics of the site, and the hazards of operation at this location.

Nuclear Aircraft Program. I—Nuclear Plane Construction Feasible Now. II—Scientists Aim at Nuclear Plane Test Data. J. S. Butz, Jr. *Av. Week*, Mar. 30; Apr. 6, 1959, pp. 86, 88, 90, 91; 87, 89, 91–109 (ff.). Discussion of the possibility of constructing a nuclear aircraft with available knowledge. A detailed description of the equipment and techniques developed to date is also presented.

Energie Nucléaire et Propulsion Aérienne. II—Etudes et Réalisations Mondiales. J. Truelle. *Docaéro*, Jan., 1959, pp. 19–32. In French. Survey covering the development of nuclear propulsion for aircraft and missiles in U.S.A., U.S.S.R., and U.K.

Electron Spin Resonance Studies of Radiation Damage to the Nucleic Acids and Their Constituents. Howard Shields and Walter Gordy. *Duke U. Dept. Phys. Microwave Lab. Rep. 24 (AFOSR TN 59-53)* [*AD 209424*], Nov. 1, 1958-Feb. 1, 1959. 15 pp. 14 refs.

Paramagnetic Resonance Study of Irradiation Damage in Crystalline Carbohydrates. Dudley Williams, J. E. Geusic, M. L. Wolfrom, and L. J. McCabe. (*Natl. Acad. Sci. Proc.*, Nov., 1958, pp. 1,128–1,136.) *Ohio State U. Res. Found. (P-563) TN 7 (AFOSR TN 58-840)* [*AD 203082*], Jan., 1959. 9 pp. 14 refs. Reprint.

Electron Spin Resonance Studies of Radiation Damage to Certain Lipids, Hormones, and Vitamins. H. N. Rexroad and Walter Gordy. *Duke U. Dept. Phys. Microwave Lab. Rep. 24 (AFOSR TN 59-54)* [*AD 209425*], Nov. 1, 1958-Feb. 1, 1959. 18 pp.

A Numerical Method for Obtaining Monoenergetic Neutron Flux Distributions and Transmissions in Multiple-Region Slabs. Appendix A—**Calculation of Transfer Probabilities and Lumping Error.** Appendix B—**Angular Distribution and First-Collision Distribution Due to an Anisotropic Source Plane.** Appendix C—**Evaluation of Integrals for Probability of Transmission with no Collision and One Collision.** Appendix D—**Numerical Treatment of Slab of Sketch.** Appendix E—**Monte Carlo Calculation of Neutron Flux and Transmission Integrals.** Appendix F—**P_3 Spherical Harmonics Solution.** Harold Schneider. *U.S., NASA Memo. 2-23-59E*, Feb., 1959. 55 pp.

Photography

Electronic Contrast Selector and Grain Spacing to Light Intensity Translator for Photographic Enlargements. R. K. H. Gebel. *USAF WADC TN 58-110* [*AD 151178*], Apr., 1958. 8 pp.

Synchronisation Electromagnétique Appliquée à un Problème de Cinématographie. R. Jaeger. *La Recherche Aéronautique*, Jan.-Feb., 1959, p. 55. In French. Description of a technique applying electromagnetic synchronization to the photographic equipment used for flow visualization.

Physics

Stationary Relativistic Motions of a Gas in a Conducting Medium. K. P. Staniukovich. (*Zhurnal Teoret. i Exper. Fiz.*, Sept., 1958, pp. 762–765.) *Sov. Phys. - JETP*, Mar., 1959, pp. 529–531. Translation. Study of the quasi-unidimensional flow of a gas in a medium with infinite conductivity and with a magnetic field perpendicular to the velocity. The total momentum which an expanding gas can acquire per unit time with and without a field is calculated.

Über den Brechungsindex von Wasserdampf-Luft-Gemischen bei Dezimeter- und Zentimeterwellen. M. Vogel. *DVL Bericht No. 76*, Dec., 1958. 77 pp. 67 refs. Westdeutscher Verlag, Köln & Opladen. In German. Presentation of the refraction index for steam-air mixtures at dm. and cm. wavelengths, and determination of the effect of index variations on the propagation of electromagnetic waves through the troposphere.

Effect of Neutron Bombardment on the Magnetic Properties of Iron. Giuseppe Biorci, Guido Bonfiglioli, Andrea Ferro, and Giorgio Montalenti. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 1b (AFOSR TN 58-1096)* [*AD 207507*], Sept., 1958. 49 pp. 49 refs.

I—Magnetic Viscosity in Iron Due to Carbon Atoms Anchored in Dislocations. Appendix I—**General Remarks on the Mechanical and Magnetic Relaxations. II—Magnetic Viscosity Due to Dislocations.** Appendix II—**Theory of F. Vicena on the Interaction Between Bloch Walls and Dislocations, and on the Coercive Force Due to Dislocations.** Giuseppe Biorci, Andrea Ferro, and Giorgio Montalenti. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 2a (AFOSR TN 59-85)* [*AD 210145*], Oct., 1958. 62 pp. 46 refs.

Measurements of Ultrasonic Wave Velocities and Elastic Moduli for Small Solid Specimens at High Temperatures. H. J. McSkimin. *ASA J.*, Mar., 1959, pp. 287–295. 30 refs. Description of an improved buffer rod-specimen unit for measuring longitudinal wave velocities in solids and for determining elastic moduli of single crystals. The use of molten metals to provide coupling at higher temperatures is discussed. Two methods involving mode conversion at an impedance discontinuity for measuring shear wave velocities are described; application to crystals of cubic symmetry is detailed.

Betrachtungen über einen elektrokinetischen Generator. A. Walz. *DVL Bericht No. 82*, Nov., 1958. 17 pp. Westdeutscher Verlag, Köln & Opladen. In German. Description, based on the Helmholtz concept, of the operation of an electrokinetic generator.

The Band Between Microwave and Infrared Regions. I. Kaufman. *IRE Proc.*, Mar., 1959, pp. 381–396. 80 refs. Discussion covering some aspects of ultramicrowave generation and the associated problems of detection, control, transmission, and measurement.

Effects of Atomic Electrons on p-p and n-p Scattering. G. Brait. *Yale U. Paper* (*AFOSR TN 58-730*) [*AD 162265*], Aug. 15, 1958. 6 pp.

Metastability of $2s$ State of Hydrogenic Atoms. J. Shapiro and G. Breit. *Yale U. Paper* (*AFOSR TN 58-817*) [*AD 202642*], Sept. 4, 1958. 11 pp.

Orbital Storage of Cryogenic Fluids. K. R. Cramer. *USAF WADC TN 58-282* [*AD 203527*], Oct., 1958. 7 pp. Presentation of a radiative heat-transfer analysis of large spherical liquid hydrogen storage vessels located in an equatorial orbit.

Eksperimental'noe Issledovanie Statistícheskikh Kharakteristik Mertsaniia Nazemnogo Istochnika Sveta. A. S. Gurvich, V. I. Tatarskii, and L. R. Tsvang. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 655–658. 15 refs. In Russian. Experimental investigation of statistical characteristics of scintillation for the case of a terrestrial light source, using the basic concepts of the theory of local isotropic turbulence.

O Nekotorykh Voprosakh Teorii Perenosa Izlucheniia i Luchistogo Teploobmena v Pogloshchaiushchei Srede. Iu. A. Surinov. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 813–816. In Russian. Study covering certain problems in the theory of radiation transfer and radiative heat exchange in absorbing media.

The Proof of Certain Laws of Optics Used in Solar Furnace Calculations. A. W. Simon. *USAF MDC TN 59-1* [*AD 209326*], Mar., 1959. 7 pp.

Effect of Diffusion on the Formation of a Pulsed Ultra-High-Frequency Discharge in Argon. T. S. Abramova and V. E. Golant. *Sov. Phys. - Tech. Phys.*, May, 1958, pp. 1,022–1,026. Translation. Experimental investigation of the dependence of critical field intensity for the formation of a pulsed ultra-high-frequency discharge in argon as a function of the dimensions of the discharge volume.

Probeg Medlennykh Vtorichnykh Elektronov v Metalle i Rol' Neuprugo Otrazhennykh Elektronov vo Vtorichnoi Elektronnoi Emissii. I. M. Bronshtein and R. B. Segal'. *AN SSSR Dokl.*, Dec. 1, 1958, pp. 639–642. In Russian. Experimental determination of the free path of slow secondary electrons in metals and the role of inelastically reflected electrons in the secondary electron emission.

Uses of Approximate Wave Functions. Charles Schwartz. *Ann. Phys.*, Feb., 1959, pp. 170–177. 11 refs. AFOSR-supported presentation of a method for using approximate wave functions to calculate the properties of the system other than the energy. The method is based on a form of the perturbation theory. Several examples, based on the two-electron atom, are worked out.

Calculations in Schrödinger Perturbation Theory. Charles Schwartz. *Ann. Phys.*, Feb., 1959, pp. 156–169. 13 refs. AFOSR-supported evaluation of second- and higher-order perturbations of the energy by iterative solution of Schrödinger's equation. Several examples are worked out for the hydrogen atom.

The Use of Fourier Transforms for the Study of Singular Points in the Frequency Spectrum of a Crystal. J. Peretti and A. Maradudin. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-155 (AFOSR TN 59-21)* [*AD 208751*], Nov., 1958. 9 pp.

The Optical Spectrum of Co^{2+} in the Cubic Crystalline Field of CaF_2. R. Stahl-Brada and W. Low. *Hebrew U. Dept. Phys. TN 4 (AFOSR TN 58-1036)* [*AD 206485*], July, 1958. 23 pp. 16 refs.

Cross Section for Al^{27} $(\gamma,2p)Na^{25}$ Reaction to 65 Mev. L. B. Auil and W. D. Whitehead. (*Phys. Rev.*, June 1, 1958, pp. 1,113–1,115.) *USAF OSR TN 48-81* [*AD 148129*], 1958. 3 pp. 23 refs. Reprint.

Experiments on the Surface Electrical Conduction in Metals. II. Guido Bonfiglioli and Renato Malvano. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 2a (AFOSR TN 59-86)* [*AD 210146*], 1958. 26 pp.

Electron Microscopy Study of Surface Structures in High Purity Al and in Al/4% Cu Alloy. II. Guido Bonfiglioli, Andrea Ferro, and Adriana Mojoni. *Inst. Elettrotec. Naz. "Galileo Ferraris" TN 2c (AFOSR TN 58-1091)* [*AD 207588*], 1958. 26 pp.

The State of a Solid Body. E. Grüneisen. (*Handbuch Phys.*, vol. 10, 1926, pp. 1–52.) *U.S., NASA RE-2-18-59W*, Feb., 1959. 76 pp. 108 refs. Translation. Study of thermodynamic properties of solids from the molecular-

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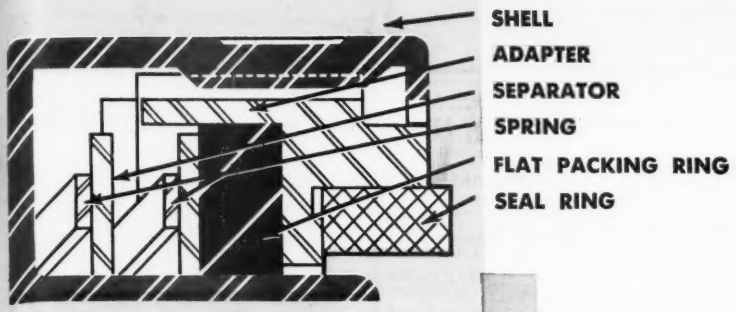

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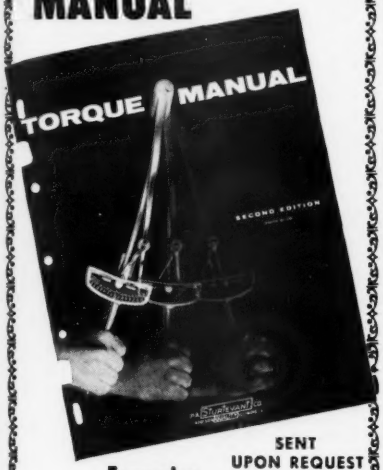

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Issledovanie Svobodnykh Radikalov, Obrazuiushchikhsia v Tverdykh Telakh v Protsesse Obluchenija Bystrymi Elektronami. Iu. N. Molin, A. T. Kopitskii, N. Ia. Buben, and V. V. Voevodskii. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 882, 883. In Russian. Investigation of free radicals formed in solids subjected to bombardment by fast electrons.

Obshchee Vyrazhenie dlia Fazovoi Plotnosti Konechnykh Statsionarnykh Osesimmetrichnykh Samogravitiruiushchikh Zvezdnykh Sistem i ikh Differentsial'noe Osevoe Vrashchenie. G. M. Idlis. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 994–997. In Russian. Presentation of a general expression for the phase density of finite stationary axisymmetric self-gravitating stellar systems and their differential axial rotation.

Effect of Vertical Drifts on the Nocturnal Ionization of the Lower Ionosphere. M. N. Rao and A. P. Mitra. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 271–290. 18 refs.

The Temperature in the Atmospheric Region Emitting the Nightglow OI 5577 Line and in Regions Above Faint Auroral Arcs. E. B. Armstrong. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 205–216. 32 refs.

Triple-Splitting of the *F*-Echoes. R. Satyanarayana, K. Bakhru, and S. R. Khastgir. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 201–204. 16 refs. Survey of polarization studies on triple *F*-echoes obtained by employing wave pulses of frequency 3 mc./sec. at vertical incidence.

Lunar Tides in the Sporadic *E*-Layer at Ibadan. R. W. Wright and N. J. Skinner. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 217–221. Analysis of semi-diurnal lunar tides in *fEs* and *h'Es*, and comparison of the results obtained with those of other stations.

A Survey of the Present Knowledge of Sporadic-*E* Ionization. J. A. Thomas and E. K. Smith. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 295–314. 144 refs.

Ionospheric Changes at Singapore During the Solar Eclipse of 14 December 1955. C. M. Minnis. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 346–350.

Solar Spectral Irradiance and Vertical Atmospheric Attenuation in the Visible and Ultraviolet. L. Dunkelman and R. Scolnik. *OSA J.*, Apr., 1959, pp. 356–367. 32 refs. Determination of the solar spectral irradiance outside the earth's atmosphere by Langley's method of extrapolation to zero air mass.

A Bistatic Radio Investigation of Auroral Ionization. C. Collins and P. A. Forsyth. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 315–345. 32 refs. Study of the scattering of radio waves in the upper atmosphere during auroral disturbances by means of a number of radio systems. A brief description of the equipment used, the geographical distribution of the paths, and the method of analysis is made and results are discussed.

The Effects of Ionospheric Irregularities and the Auroral Zone on the Bearings of Short-Wave Radio Signals. H. A. Whale. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 258–270. 12 refs.

Observations of Meinel N_2+ Bands Near 1.5 μ in the Auroral Spectrum. A. W. Harrison and A. V. Jones. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 291–294. 10 refs. USAF-sponsored research.

Meteorological "Angel" Echoes. David Atlas. *J. Meteorology*, Feb., 1959, pp. 6–11. 11 refs. Description of recent findings and associated implications of the radar detection of refractive index gradients.

O Rasseianii i Poliarizatsii Sveta v Atmosfere v Usloviiakh Liviiskoi Pustyni. E. V. Piaskovskaia-Fesenkova. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 1,006–1,009. In Russian. Discussion covering the diffusion and polarization of light in the atmosphere observed over the Lybian desert.

A Study of the Equatorial Electrojet. I—An Experimental Study. II—A Model Electrojet That Fits *H*-Observations. C. A. Onwumechilli. *J. Atmos. & Terrestrial Phys.*, Feb., 1959, pp. 222–257. 30 refs.

Nuclear Explosions in Space. I, II. S. F. Singer. *Missiles & Rockets*, Mar. 30; Apr. 6, 1959, pp. 33–36; 36–38. Presentation of a scientific explanation of Project Argus and discussion of how an electron accelerator could lead to the creation of an artificial particle belt. The problem of nuclear explosions in space and their direct effect upon space vehicles carrying men or nuclear warheads is covered.

Radiation Corrections to Bremsstrahlung. P. I. Fomin. (*Zhurnal Teoret. i Exper. Fiz.*, Sept., 1958, pp. 707–718.) *Sov. Phys.-JETP*, Mar., 1959, pp. 491–498. Translation. Computation of radiation corrections to the differential cross section for bremsstrahlung using the mass operator method. A general formula is obtained and some limiting cases are considered.

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Power Plants

Propulsion Supersonique par Turboréacteurs et par Statoréacteurs. M. Roy. *Docaéro*, Jan., 1959, pp. 3–18. 12 refs. In French. Study covering supersonic propulsion by turbojets and ram-jets. Includes survey of basic principles and definition of performance parameters; matching characteristics of components; importance of intake design; typical performance of ram-jets and turbojets with afterburners; compound power plants; and some VTOL arrangements for blown flaps and jet deviation.

The Propulsion Spectrum. *Flight*, Mar. 20, 1959, pp. 381–387. Review of the propulsion requirements of a wide range of flight vehicles including those for outer space flight.

Choice of Engines for Aircraft. W. A. Pennington. *Shell Av. News*, Jan., 1959, pp. 14–19. Discussion of the various stages in the choice of an engine for a new aircraft design. These include the type of power plant, the number of engines, and the choice of a particular engine. For the last stage, cost, availability, engine specific weight, and aircraft growth factors are considered.

Aero Engines 1959. *Flight*, Mar. 20, 1959, pp. 388–412. Design and performance characteristics for jet-turbine, liquid-rocket, reciprocating, and ram-jet engines of the world.

Jet & Turbine

Vergleich von Gleichdruck- und Verpuffungsgasturbinen. K. Graf. *DVL Bericht No. 65*, Aug., 1958. 112 pp. 27 refs. Westdeutscher Verlag, Köln & Opladen. In German. Comparison of impulse and intermittent combustion turbines considering the systems both with and without regenerating processes, for cooled and uncooled compression, heated and unheated expansion.

Experimental Evaluation of Cermet Turbine Stator Blades for Use at Elevated Gas Temperatures. P. T. Chiarito and J. R. Johnston. *U.S., NASA Memo. 2-13-59E*, Feb., 1959. 25 pp. Investigation demonstrating that under carefully controlled operating conditions the life of cermet turbine stator blades would probably be acceptable at temperatures that would yield substantial increases in thrust. The method of support is shown to be an important problem, but indications are provided making it readily solvable.

Application of Gas Analysis to Combustor Research. R. R. Hibbard and Albert Evans. *U.S., NASA Memo. 1-26-59E*, Feb., 1959. 22 pp. Evaluation of the ability of gas-analytical techniques to determine the performance of turbojet and ram-jet combustors. Gas samples were taken at the outlet and two upstream stations and their compositions were determined.

T63 Designed for Low Cost Production. E. I. Bulban. *Av. Week*, Apr. 6, 1959, pp. 73, 75–77, 80, 81, 83. Presentation of basic features of the Allison 250-s.hp. turbine power plant designed for low cost, light weight, simplicity, and reliability.

"Power Package" for Electra. J. P. Kushnerick. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 14–17. Review of the design, development, and operation of the engine. Lubrication and fuel control are also considered.

The Origin of the Bypass and Ducted Fan. D. L. Brown. *The Aeroplane*, Mar. 13, 1959, pp. 313–316. Discussion covering the development of the bypass engine in England.

Vibration Testing Jet Engines. G. E. Billman. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 26–29. Discussion of the use of small electromagnets for vibration testing, including the advantages of this method. The test setup and procedure are described.

Ram-Jet & Pulse-Jet

Ramjet Trends. Eugene Perchonok. *Astronautics*, Apr., Pt. I, 1959, pp. 40, 41, 100–102. Evaluation of trends in ram-jet engine development and survey of current ram-jet applications.

Ramjet Fuel-Air Control. Ludwig Muhlfelder. *Astronautics*, Apr., Pt. I, 1959, pp. 42, 43, 86. Review of some fuel-air control fundamentals; the open and closed control metering loops are considered.

Ramjet Combustion. Roland Breitwieser. *Astronautics*, Apr., Pt. I, 1959, pp. 44, 45, 87, 88, 90. Discussion of the extreme variance of ram-jet combustors and of the wide range of operating conditions. Combustion principles for various Mach Numbers are considered.

A Future for Hypersonic Ramjets. G. L. Dugger. *Astronautics*, Apr., Pt. I, 1959, pp. 38, 39, 114–117. Discussion of the future use and importance of hypersonic ram-jets. Performance and design characteristics are considered.

Rocket

The Rocket: An Old Idea, and Old Challenge. S. B. Kramer and Nancy Putnam. *Astronautics*, Apr., Pt. II, 1959, pp. 15–17. Brief history of rocket propulsion development.

Rocket Propulsion. Ch. J. Marsel. *Astronautics*, Apr., Pt. II, 1959, pp. 7–11. Discussion of some rocket propulsion fundamentals, and of liquid and solid propellants with their respective properties and advantages.

The de Havilland Spectre I. W. N. Neat. *RAeS J.*, Feb., 1959, pp. 104–112. Discussion of the development and design characteristics of the Spectre I engine. Rig, flight, and bench testing are described and future developments considered.

X-15 Engine Will Have Wide Space Use. Michael Yaffee. *Av. Week*, Mar. 30, 1959, pp. 59–62, 64, 65. Survey covering such factors as the development, geometry, shut-down cycle, sensing devices, firing duration, and operational aspects of the XLR99-RM-1 rocket engine.

Thrust of a Conical Nozzle. E. M. Landsbaum. *ARS J.*, Mar., 1959, pp. 212, 213. Review of the equations for calculating the thrust of a conical nozzle and demonstration of their correct use.

Liquid Injection for Solid Rocket Thrust Control. Michael Grenus. *Space/Aeronautics*, Apr., 1959, pp. 59–61, 63. Evaluation of three liquids (water, ethylene oxide, a mixture of hydrogen peroxide and hydrazine 6) with regard to the effects of injection on thrust variables. Propulsion systems and overall missile weight penalties are discussed as are thrust control ranges.

Thrust Control of Solid Propellant Rockets. H. W. Ritchey. *Western Av.*, Mar., 1959, pp. 32–34. Discussion of fundamental principles of thrust vector control, thrust termination, and thrust modulation.

General Equation for Rocket Velocity. Sylvan Rubin. *ARS J.*, Mar., 1959, pp. 219, 220. Presentation of an equation for the final velocity of a rocket using any propulsion system derived in terms of the exhaust velocity, the specific fuel energy, and the mass ratios of fuel and propellant to the rocket mass at burnout.

Production

De Havilland Comet; Mainplane Assembly: Stub-Wing to Centre-Section Joint. IV. W. E. Goff. *Aircraft Prod.*, Apr., 1959, pp. 127–138.

A4D's "Tadpole Rudder." *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 10–12. Discussion covering the manufacturing process and the materials used.

Convair 880. R. W. Peters. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 33–40. Description of structural design, tooling equipment, and assembly.

Metalworking

High-Nickel Airframe; Use of Inconel X in the North American X-15. *Aircraft Prod.*, Apr., 1959, pp. 122–126. Brief description of production techniques that involved hot- and cold-machining, chemical contour-etching, heat treatment, refrigeration treatment, resistance welding, and inert-gas arc welding.

Adhesive Bonding; Fairchild Production Processing and Tooling Techniques. D. E. Winter. *Aircraft Prod.*, Apr., 1959, pp. 150–159. Discussion that includes surface preparation, bonding equipment, bonding in contour, and bonding flat assemblies.

Stretch-Form Tooling. *Aircraft Prod.*, Apr., 1959, pp. 139–149. Description of the tooling required and production methods for a door-frame post and a fuselage skin-panel, both of double-bubble configuration and both formed on a large Hufford machine.

Cavity Formation and Enfolding Defects in Plane Strain Extrusions Using a Shaped Punch. W. Johnson. *Appl. Sci. Res., Sect. A*, No. 2-3, 1959, pp. 228–236. Development of expressions for a best upper bound to the load necessary to cause extrusion through square dies, using a punch face inclined to the axis of the extrusion container. The choice of the punch face angle which delays the onset of cavity deformation and the enfolding of oxide surfaces are considered.

Application of Statistical Analysis to the Classification of Surface Finishes and to Their Examination. M. Gombaud. (*L.C.A. Etude No. 11-100; Note No. 17, 1956.*) *Gt. Brit., MOS TIL T/T4813*, Jan., 1958. 37 pp. Translation.

Effects of Hydrogen Brazing on Properties of High-Temperature Alloys. G. S. Hoppin, III, and E. N. Bamberger. *Welding J. Res. Suppl.*, Apr., 1959, pp. 194-s–201-s. Description of investigations to define quantitatively the extent of changes in base-metal strength resulting from brazing temperatures. Eight alloys currently used for high-temperature jet-engine components were subjected to brazing thermal cycles and subsequently tested for tensile and stress-rupture properties.

Electric-Blanket Brazing. D. E. Wernz. *Aircraft & Missiles Mfg.*, Apr., 1959, pp. 20–23. Description of a new approach to fabricating stainless-steel sandwich using portable equipment.

Quartz-Lamp Radiant Brazing of Titanium-Alloy Honeycomb Sandwich Panels. J. F. Rudy, R. M. Necheles, and Harry Schwartzbart. *Welding J. Res. Suppl.*, Apr., 1959, pp. 202-s–208-s. Description of the brazing process and discussion of its expansion to full-sized production panels. The selection of titanium alloys for panel cover sheets is considered.

Development of Brazed Sandwich Construction Materials for High Temperature Applications. II. Ch. F. Burrows and F. J. Ragland, Jr. *USAF WADC TR 55-463, Pt. II [AD 155725]*, July, 1958. 105 pp. Investigation to develop the optimum combinations of base metals and brazing alloys to withstand operational temperatures up to 1,200°F. Static flexure and edgewise compression data for all combinations are given, and flexural fatigue curves are presented.

Butt Welding Proves Out for Thin Gages. G. C. Close. *Space/Aeronautics*, Apr., 1959, pp. 81, 82, 84, 86. Description of the production facilities needed for butt welding and discussion of the various applications of this process.

Inert-Gas Metal-Arc Welding for Aluminium Sheet and Strip. J. E. Tomlinson. *Light Metals*, Mar., 1959, pp. 73–76. Description of welding equipment and the range of operation of the process.

Ultrasonics and Welding. J. N. Antonevich and R. E. Monroe. *Battelle Tech. Rev.*, Mar., 1959, pp. 9–13. Description of the basic mechanism and application of the ultrasonic welding process.

Production Engineering

Facteurs d'Economie dans l'Industrie Aéronautique. M. Etesse. *Tech. & Sci. Aéronautiques*, Oct., 1958, pp. 203–220. In French. Review of economic factors in the aeronautical industry, including such aspects as engineering organization, manufacturing services, and design and production engineering.

Reliability

What Price Unreliability? II. D. A. Griffin. *Missile Des. & Devel.*, Mar., 1959, pp. 26, 28. Analysis covering the shortcomings of component parts and their effect on weapons systems.

Multi-Factor Experiments. M. Zelen and W. S. Connor. *Ind. Quality Control*, Mar., 1959, pp. 14–17. Study of the planning of experiments to investigate the joint effects of several factors on the performance of a piece of equipment, on the yield of a product, or on the characteristics of a test method.

A New Philosophy of Electrical Component Acceptance. H. G. Harding and R. A. Hulnick. *Ind. Quality Control*, Mar., 1959, pp. 8, 9.

Research, Research Facilities

Preliminary Investigation of Hyper Environments and Methods of Simulation. II—Simulation Methods. I. J. Lamb and R. A. Ditaranto. *USAF WADC TR 57-456, Pt. II [AD 142167]*, Nov., 1957. 79 pp. 119 refs. Analysis of the environments investigated in Phase I and presentation of methods for simulating these environments individually and in combination. The measurement techniques and equipment used for each simulation method are discussed, and the recording data are outlined.

GOX Laboratory Simulates Combined Environments. *Space/Aeronautics*, Apr., 1959, pp. 103, 106, 110, 112. Description of types of equipment and their capabilities for testing such missile components as cryogenic dump valves.

Reliability Testing Using Rotary Accelerators. M. L. Aronow. *Aero/Space Engrg.*, May, 1959, pp. 48–52. Discussion of the development of the rotary accelerator as an environmental test or instrument calibration device. The machine is capable of producing a constant acceleration over a sustained interval.

Quelques Points Particuliers de la Technique d'Excitation en Vol par Vibreurs Harmoniques. G. de Vries. *La Recherche Aéronautique*, Jan.-Feb., 1959, pp. 47–53. In French. Discussion covering specific problems involved in the design of a harmonic vibrator for flight measurements.

Martin-Denver Rocket Test Facility. R. S. Williams. *Western Av.*, Mar., 1959, pp. 22, 23, 40–43. Description of programs and test facilities to ground-test the Titan missile.

Analytical Techniques for Systems Studies. J. C. Bellamy, R. V. Clark, and W. A. Bohan. *Cook Tech. Rev.*, Dec., 1958, pp. 1–14. Presentation of a systems analysis approach, based on classification procedures, for the study of large

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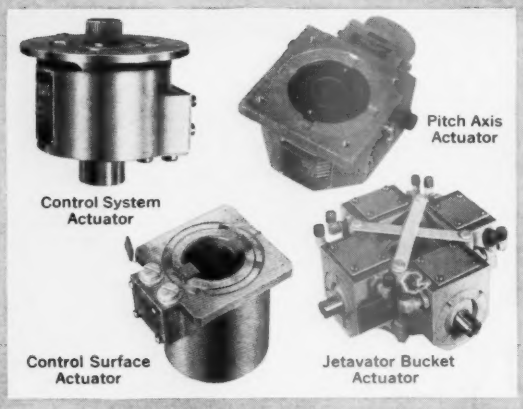

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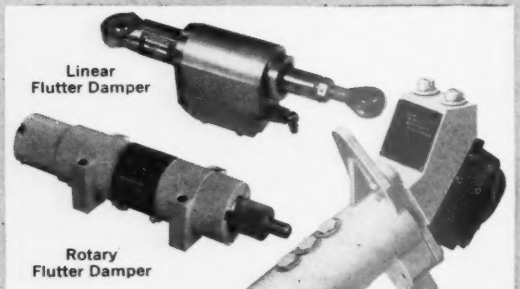

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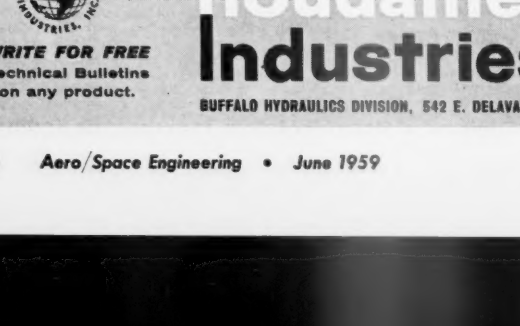

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scale equipment systems. To illustrate the method, the concepts of operational elements are developed for general physical data processing systems.

Flight Testing

Airborne Equipment for Recording Aircraft Flight Paths. J. C. Simons and W. H. Richardson. *USAF WADC TN 58-37 [AD 131058]*, June, 1958. 32 pp. Description of the Flight Path Recording System designed to continuously record air speed, altitude, pitch, roll, and heading. The capability and reliability of the recording systems are reviewed, and general operating and calibrating procedures are established.

Research Methods and the Full-Scale Test Aircraft. R. A. Cole. *Aeronautics*, Apr., 1959, pp. 26–30. Presentation of data on past and present research aircraft and discussion of their importance.

Wind Tunnels

Aperçu sur les Possibilités Expérimentales du Tunnel Hydrodynamique à Visualisation de l'O.N.E.R.A. H. Werlé. *France, ONERA NT 48*, 1958. 35 pp. 42 refs. In French. Survey covering the experimental potentialities of the ONERA hydrodynamic tunnel, the equipment and methods of flow visualization, as well as certain types of recently performed tests.

Electric Arc Gas Heaters for Re-Entry Simulation and Space Propulsion. T. R. Brogan. (*Avco Res. Lab. RR 35, Sept., 1958.*) *ARS 13th Annual Meeting, New York, Nov. 17–21, 1958, Preprint 724-58.* 29 pp.

Luminescent Gas Flow Visualization in a Low-Density Supersonic Wind Tunnel. W. B. Kunkel and F. C. Hurlbut. *USAF WADC TR 57-441 [AD 151007]*, Sept., 1957. 55 pp. 27 refs. Discussion of afterglow mechanisms in nitrogen, air, argon, and helium. The range of practicability of the enriched air glow technique is found to extend from Mach Numbers 2 to 4. Argon and helium glows are found to be useful in the range from Mach Numbers 1.3 to 2.

Microschlieren; A Technique for the Study of Details in Compressible Flow. W. S. Bradfield and J. J. Sheppard, Jr. *Aero/Space Engrg.*, May, 1959, pp. 37–40, 56. AFOSR-supported development of a technique that permits the investigation of flow regimes outside the range of commonly used visualization techniques. Particular emphasis is placed on high aperture, short focal length objectives working with short optical path lengths.

Notes on Some Simple Strain Gauge Networks Commonly Used with Wind Tunnel Balances. J. R. Anderson. *Gt. Brit., ARC CP 415* (Aug., 1958) 1959. 14 pp. BIS, New York, $0.45.

Summary of Instrumentation Development, and Aerodynamic Research in a Hypersonic Shock Tunnel. I. Ch. E. Wittliff and George Rudinger. *USAF WADC TR 58-401, Pt. I [AD 155758]*, Aug., 1958. 65 pp. 32 refs. Development and application of instrumentation and techniques for obtaining experimental aerodynamic data in the hypersonic shock tunnel. The flow in the shock tunnel is studied, and a preliminary theoretical analysis of the flow about yawed cones at hypersonic speeds is made.

AGARD Wind Tunnel Calibration Models. *NATO AGARD Wind Tunnel & Model Testing Panel Spec. 2*, Sept., 1958. 19 pp. In English and French.

Finishing and Inspection of Model Surfaces for Boundary-Layer-Transition Tests. M. E. Wilkins and J. F. Darsow. *U.S., NASA Memo. 1-19-59A*, Feb., 1959. 17 pp.

Maquettes Propulsées de Flottement; Contrôle des Coefficients Aérodynamiques Instationnaires. R. Dat and R. Destuynder. *La Recherche Aéronautique*, Jan.-Feb., 1959, p. 56. In French. Description of a method for studying flutter by measuring nonstationary aerodynamic coefficients on four models.

Rotating Wing Aircraft, Helicopters

Brief Notes on Helicopter Performance with Particular Reference to the Anti-Submarine Role. W. Stewart. *Gt. Brit., RAE TM Nav. 125*, Oct., 1958. 8 pp.

Theory of Self-Excited Mechanical Oscillations of Helicopter Rotors with Hinged Blades. Appendix A, B—**The General Equations of Motion for Two-Blade Rotors.** G. W. Brooks. Appendix C—**Derivation of the Convergence Factor for $K(O)$.** Appendix D—**Mathematical Analysis for the Case of $K_y = \infty$.** R. P. Coleman and A. M. Feingold. *U.S., NACA Rep. 1351*, 1958. 39 pp. Supt. of Doc., Wash., $0.45.

Maximum Mean Lift Coefficient Characteristics at Low Tip Mach Numbers of a Hovering Helicopter Rotor Having an NACA 64$_1$ A012 Airfoil Section. R. D. Powell, Jr. *U.S., NASA Memo. 1-23-59L*, Feb., 1959. 25 pp. 10 refs.

Safety

Passenger Survival in Aircraft Crashes. D. I. Fryer. *Aeronautics*, Apr., 1959, pp. 31–37. 29 refs. Discussion of the factors governing survival, with particular reference to seat arrangements, and examination of results of experiments on man.

Space Travel

Mechta's Trip Past Moon May Have Been Intentional. W. A. Daley and D. H. Robey. *Av. Week*, Mar. 30, 1959, pp. 66, 67, 69, 71, 72. Discussion proposing (a) that due to the large payload, launching time, cutoff velocity, and trajectory, the heliocentric orbit of Mechta was a goal rather than the result of a miscalculation; and (b) that Mechta may be part of a program to determine the Astronomical Unit (mean distance between sun and earth). The payload is analyzed with respect to power requirements, and other weight estimates are made.

A Short Form Method for Determining Near-Circular Orbit Quantities. J. N. Benezra. *ARS J.*, Mar., 1959, pp. 216–219. Presentation of a method which has the advantage of expressing various orbit quantities of interest and their sensitivity to injection errors as explicit functions of the injection errors and altitude.

Infrared Detection from Recon Satellites. II. *Space/Aeronautics*, Apr., 1959, pp. 151, 153, 154, 156. Analysis of factors affecting a infrared mapping system. Atmospheric transmission spectrum of earth's radiation, bandwidths, altitude, and temperature effects on resolution are presented.

Transoceanic Communication by Means of Satellites. J. R. Pierce and R. Kompfner. *IRE Proc.*, Mar., 1959, pp. 372–380. Discussion of the feasibility of satellite communication orbits, visibility, path-loss calculations, modulation systems, and other related problems.

Structures

The Economy of Structures. Alfred Pugsley. *RAeS J.*, Mar., 1959, pp. 153–162. 21 refs. Historical survey covering early aeronautical structures, figures of merit, economy and performance, and other factors.

Exact Results for the Bending Shear Stress Distribution for Some Simple Sections. J. L. Taylor. *RAeS J.*, Mar., 1959, pp. 181, 182. Presentation of results for a wedge, a double wedge, a biconvex section, and an airfoil-type section.

The Critical Load of a Triangular Framework When Lateral Buckling Occurs. J. G. Nutt. *Appl. Sci. Res., Sect. A*, No. 2–3, 1959, pp. 169–176. Evaluation of the critical buckling load, using matrix algebra. The joints are assumed to be fixed in position in space but free to rotate.

Numerical Integration Simplifies Complex Design. E. E. Ungar. *Prod. Eng.*, Mar. 16, 1959, pp. 50–54. Presentation of a tabular method for evaluating integrals, and application to six examples of beams and shafts with complex loading.

Cylinders & Shells

Ob Ustoichivosti Tsilindricheskikh Obolochek pri Dinamicheskom Nagruzhenii. A. S. Vol'mir. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 806–808. In Russian. Study of the stability of cylindrical shells subjected to dynamic loading.

Elasticity & Plasticity

On a Mean Value Theorem, and its Converse, for the Displacements in the Theory of Elasticity. J. B. Diaz and L. E. Payne. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-161 (AFOSR TN 59-212) [AD 211666]*, Jan., 1959. 7 pp. Presentation of proof for a mean value theorem using only the corresponding theorem of Gauss, and its converse, in potential theory.

Ob Odnom Chastnom Reshenii Obshchikh Uravnenii Teorii Ideal'noi Plastichnosti v Tsilindricheskikh Koordinatakh. D. D. Ivlev. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 988–990. In Russian. Derivation of a partial solution for the general equations of the theory of ideal plasticity in cylindrical coordinates.

Smeshannaia Zadacha dlia Uprugogo Sloia. Ia. S. Ufliand. *AN SSSR Dokl.*, Dec. 21, 1958, pp. 991–993. In Russian. Derivation of an exact solution for the spatial problem in the theory of elasticity for the case of an infinite elastic layer.

Plates

Approximate Analysis of Effects of Large Deflections and Initial Twist on Torsional Stiffness of a Cantilever Plate Subjected to Thermal Stresses. Appendix A—**Discussion of Modal Functions Used in the Analysis.** Appendix B—**Evaluation of Integrals and Related Functions.** R. R. Heldenfels and L. F. Vosteen.

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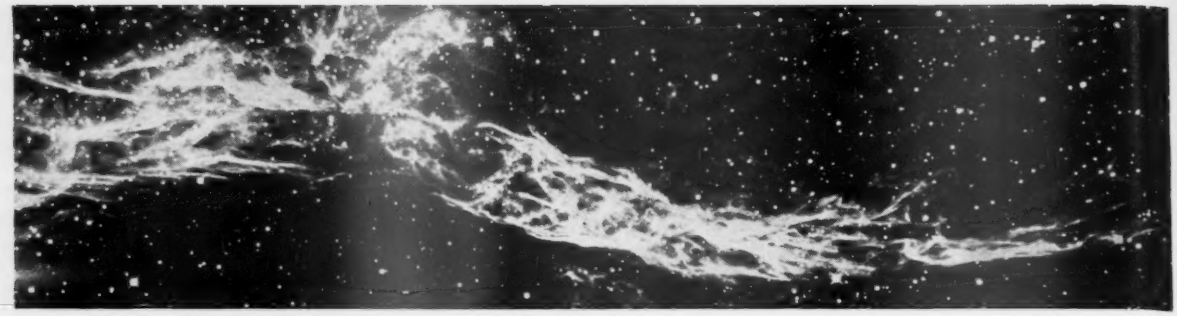

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Rings

Thermal Stresses in Rings. Marvin Forray. *J. Aero/Space Sci.*, May, 1959, pp. 310, 311.

Sandwich Construction

Six Basic Design Rules for Brazed Honeycomb Sandwich. F. F. Rechlin. *Materials in Des. Eng.*, Mar., 1959, pp. 100–104. Presentation of six rules, the first four concerning the effect of brazing on design and the last two on increasing the efficiency of the sandwich in the end product.

Testing Methods

Magnetostrictive Drive Techniques for Fatigue Testing of Metals Above 10 Kilocycles. P. J. Brosens, R. W. Reid, and T. P. Rona. *USAF WADC TR 57–438 [AD 205547]*, Dec., 1957. 108 pp. 15 refs. Experimental and analytical study of the impedance match problem between source and load, and evaluation of other methods of excitation and the use of existing equipment to trace fatigue development by frequency and damping measurements.

Hydro-Fatigue Test of a Large Cargo Aircraft. J. E. York. *Aero/Space Engrg.*, May, 1959, pp. 44–47, 56. Results of tests on a C-130A aircraft which had not been designed originally according to "fail-safe" concepts. The tests indicated where strengthening was needed and further showed that hydro-fatigue testing is not an adequate substitute for "fail-safe" design.

Design of the High Intensity Noise Test Facility. G. W. Kamperman. Appendix I, II—**A Siren Design for Producing Controlled Wave Forms at High Intensities.** Appendix III—**A Siren Design for Producing Controlled Wave Form with Amplitude Modulation.** C. H. Allen and B. G. Watters. *USAF WADC TR 58–367 [AD 202561]*, Oct., 1958. 99 pp.

Thermal Stress

Thermal Stresses in Design. X—Elastic Stresses by Minimizing Residuals. S. S. Manson. *Mach. Des.*, Mar. 19, 1959, pp. 191–197. 12 refs. Description of the component features of the station-function collocation method for thermal stress problems. Various applications of the procedure, as well as its advantages and limitations, are considered.

On the Representation of Nonlinear Creep by a Linear Viscoelastic Model. H. H. Hilton. *J. Aero/Space Sci.*, May, 1959, pp. 311, 312. Study showing that, under constant temperature and load, the Maxwell-Kelvin model corresponds to Baer's empirical creep formula.

Thermodynamics

Further Note on Isentropic Compressible Flow of Air with Variable Specific]Heats. K. E. Tempelmeyer. *J. Aero/Space Sci.*, May, 1959, pp. 312, 313. Presentation of six sets of empirical equations to be used in the integration of Euler's and the general energy equations.

A Study of the Effect of Temperature Separation of Air in a Direct-Flow Vortex Tube. N. S. Torocheshnikov, I. L. Leites, and V. M. Brodianskii. *Sov. Phys. - Tech. Phys.*, June, 1958, pp. 1,144–1,150. 12 refs. Translation. Study of the efficiency of a direct-flow vortex tube. It is found that vortex temperature separation occurs mainly near the nozzle. Therefore, the hypothesis of equalization of angular velocity does not correspond to the experimental observations. Under otherwise equal conditions the direct-flow vortex tube is less efficient than the counter-flow tube.

Combustion

Project SQUID Semi-Annual Progress Report. Appendix—Technical Reports, Apr. 1, 1958–Sept. 30, 1958. *Princeton U. James Forrestal Res. Cen. SQUID PR*, Oct. 1, 1958. 120 pp. 66 refs. Summary report of work done between April 1 and September 30, 1958, on fluid mechanics, transport and transfer processes, chemical kinetics, and combustion phenomena.

Transition Probability Parameters of Molecular Spectra Arising from Combustion Processes. R. W. Nicholls, P. A. Fraser, and W. R. Jarmain. *Comb. & Flame*, Mar., 1959, pp. 13–38. 37 refs. Presentation of relative transition probabilities and related data for molecular band systems which are of importance in combustion.

Recent Advances in Gaseous Detonation. R. A. Gross and A. K. Oppenheim. *ARS J.*, Mar., 1959, pp. 173–179. 101 refs. AFOSR-supported review of recent work including calculations of detonation wave propagation, the speed of sound in a reacting gaseous medium, Chapman-Jouguet and non-Chapman-Jouguet detonations, the interior of a detonation wave, and the development of detonation.

Excess Radical Concentrations and the Disappearance of Carbon Monoxide in Flame Gases from Some Lean Flames. W. E. Kaskan. *Comb. & Flame*, Mar., 1959, pp. 49–60. 14 refs.

Methane-Oxygen-Fluorine Flames Spectroscopic and Calorimetric Studies. J. J. Ball, D. E. Mann, B. A. Thrush, G. T. Armstrong, C. F. Coyle, and L. A. Krieger. *USAF WADC TR 58–541 [AD 204802]*, Oct., 1958. 63 pp. 25 refs.

The Source of the Continuum in Carbon Monoxide-Hydrogen-Air Flames. W. E. Kaskan. *Comb. & Flame*, Mar., 1959, pp. 39–48. 18 refs. Investigation of the source of continuum from flames containing carbon monoxide and oxygen by measuring both the emission intensity and [OH] in the flame gases.

Pre-Ignition and Ignition Reactions of the Propagatively Reacting System Magnesium-Sodium Nitrate-Laminac. V. D. Hogan and Saul Gordon. *Comb. & Flame*, Mar., 1959, pp. 3–12.

Heat Transfer

Heat Transfer. E. R. G. Eckert, J. P. Hartnett, and T. F. Irvine, Jr. *Ind. & Eng. Chem.*, Mar., 1959, pp. 453–465. 318 refs. Review of recent literature on conduction, channel flow, boundary-layer flow, transfer mechanism, natural convection, convection from rotating surfaces, mass transfer cooling, change of phase, radiation, liquid metals, measurement techniques, and heat-transfer applications.

Alternative Method of Correlating Forced Convection Heat Transfer Data. P. H. Price. *Brit. J. Appl. Phys.*, Mar., 1959, pp. 135–138. Derivation of an alternative correlation making explicit allowance for pipe wall temperature variations. The use of a general heat-transfer coefficient is shown to be unsatisfactory, and some implications of the correlation are discussed.

On Convective Heat Transfer Across a Spherical Cavity. G. F. Shaidurov. *Sov. Phys. - Tech. Phys.*, Apr., 1958, pp. 799–804. Translation. Investigation carried out for a Rayleigh Number range from 10^4 to 10^6 in a spherical cavity contained in a solid heat-conducting mass.

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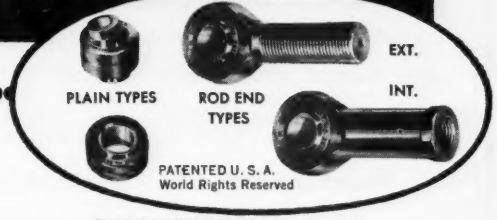

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Heat Transfer by Laminar Flow from a Rotating Disk at Large Prandtl Numbers. D. R. Davies. *Quart. J. Mech. & Appl. Math.*, Feb., 1959, pp. 14–21. Extension of the approximate method to the case of a heated rotating disc for an arbitrary radial distribution of surface temperature on the disc. A comparison of numerical results for heat transfer with those calculated from an exact solution shows that very good accuracy is obtained for Prandtl Numbers greater than six.

Peredacha Tepla Mezhdu Normal'noi i Sverkhtekuchei Fazami Zhidkogo Geliia. V. T. Khoziainov. *AN SSSR Dokl.*, Dec. 11, 1958, pp. 835–837. In Russian. Study of the heat transfer from normal to the superfluid phase of liquid helium.

On the Analysis of Heat-Exchange Apparatus. III. G. D. Rabinovich. *Sov. Phys.-Tech. Phys.*, May, 1958, pp. 1,004–1,010. Translation. Analysis considering the stationary condition of a heat-exchange apparatus for the cases of direct and counter-flow of heat-transfer media that contain no source of heat.

The Eddy Diffusivity in Annular Flow. Henry Barrow. *RAeS J.*, Mar., 1959, pp. 180, 181. Discussion of the eddy diffusivity and prediction of its distribution. Experimental results are presented.

VTOL & STOL

The Fairey Rotodyne. G. S. Hislop. *Helicopter Assn. Gt. Brit. J.*, Feb., 1959, pp. 2–49; Discussion, pp. 50–56. 13 refs. Discussion of design philosophy, aerodynamic characteristics, structural characteristics, tip propulsion, power-plant control, and piloting techniques. A brief description is given of testing programs including aerodynamic, fatigue, ground resonance, full scale rig, and ancillary system development, as well as the design and development of tip jet silencers.

Water-Based Aircraft

Effect of Convex Longitudinal Curvature on the Planing Characteristics of a Surface Without Dead Rise. E. J. Mottard. *U.S., NASA Memo. 1-25-59L*, Feb., 1959. 34 pp. Test results showing that the effects of convexity are to increase the wetted length-beam ratio (for a given lift), to decrease the lift-drag ratio, to move the center of pressure forward, and to increase the trim for maximum lift-drag ratios as compared with values for a flat surface. The effects are greatest at low trims and large drafts.

IAS Twenty-Eighth Annual Meeting

Hotel Astor, New York City, January 25–28, 1960

The scope of the meeting will be broad to cover the many interests of IAS members. The Meetings Committee invites papers to be submitted in any of the scientific fields relating to aeronautics and space.

Members or organizations wishing to have papers considered for presentation at this meeting should submit outlines or summaries to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than August 1, 1959.

Zippered nose cone cover foils moisture, dust, abrasion

To protect the polished finish of missile nose cones from assembly to countdown, B. F. Goodrich fabricated unique zippered "all-weather" Nose Cone Covers for Avco's Research and Advanced Development Division.

Made from neoprene coated nylon fabric, this shipping cover has non-rigid neoprene ribs and spacers that keep it from riding down on the cone. Special B. F. Goodrich Pressure Sealing Zippers provide easy access and removal—yet seal positively against dust, dirt, grime, damaging impact.

B. F. Goodrich was asked to engineer this special project because of its widely-known ability to manufacture coated fabrics to any shape or size—as in aircraft baggage panels. In addition, the space-saving B. F. Goodrich Zipper—used widely for air ducts, inspection ports, access doors, and aileron gap seals—withstands any pressure up to the maximum strength of the zipper itself. And it, too, can be fitted to complex contours.

Tricky sealing problems like this one are just part of the day's work at B. F. Goodrich. Next time you have such a problem and need an answer—fast—write or call *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. AS-69, Akron, Ohio.*

B.F.Goodrich ***aviation products***

Corporate Member News

(Continued from page 16)

physicist, to the Board of Directors. Dr. Williams will also serve as Scientific Adviser to Everett M. Patterson, President of the Laboratories.

• **Chicago Aerial Industries, Inc.,** has named Frank R. Demchock to the new post of Assistant Director of Customer Relations.

• **Fairchild Camera and Instrument Corp.** has appointed B. R. Hand Director of Product and Market Planning. Mr. Hand will serve on the staff of the president, with the services of his department available to the firm's divisions and subsidiaries.

• **General Dynamics Corp. . . .** Convair has named Roy R. Brewton Vice-President and Controller. Harry T. Dillon, Project Staff Engineer (Pomona), has been appointed Manager of the new field office opened at Huntsville, Ala.

• **General Electric Co. . . .** Flight Propulsion Division signed a formal agreement with the Federal Republic of Germany for the licensing of J79 jet engines. R. B. Johnson, Jr., has been appointed Manager—Marketing, Flight Propulsion Laboratory Department.

• **General Precision Equipment Corp. . . .** Kearfott Co., Inc., has begun construction of a million-dollar, two-story building across from the company's present headquarters in West Paterson, N.J.

• **Lear, Inc.,** has announced the election of James L. Anast as President, and K. Robert Hahn as Executive Vice-President. Richard M. Mock continues as Chariman of the Executive Committee. Also established was the office of "Group Vice-President" to which Andrew F. Haiduck and Roy J. Benecchi were elected.

• **Lockheed Aircraft Corp.** has announced that formation of an international subsidiary—Lockheed Aircraft International—to broaden the world market for numerous Lockheed products and services, is in advanced planning stages. Missiles and Space Division has named Roy Smelt Manager of the Discoverer satellite project.

• **Minneapolis-Honeywell Regulator Co. . . .** Aeronautical Division has named Edward R. Marshall Comptroller of the Division's plants in Minneapolis.

• **Pesco Products Div., Borg-Warner Corp.,** has named M. A. Beique, formerly Manager of Forward Planning, to the position of Advertising Manager. Lester J. Elgin has been appointed Assistant Advertising Manager.

• **Piasecki Aircraft Corp.** has announced the opening of its new Mayfield Electronics Division, Mayfield, Pa. This new facility is designed for the production of nucleonic, electronic, and electromechanical assemblies.

• **Solar Aircraft Co.** has named Dr. Ervin H. Bramhall, a physicist, Chief of Weapon Systems Analysis. Cyrus C. Haynie has been made Assistant to Plant Manager, San Diego. Herbert H. Bowie has been appointed Manager of Army Relations for the southeastern district sales office.

• **Space Technology Laboratories, Inc.,** has announced the appointment of Dr. George C. Szego as a member of the Technical Staff. His efforts will be devoted to research on advanced energy sources and propulsion systems in the Special Projects Office.

• **Sperry Gyroscope Co.** has announced the appointment of Brig. Gen. Joseph A. Bulger, USAF (Ret.), as Director of Plans and Systems, Countermeasures Division. Another building in Syosset, L.I., N.Y., is being acquired by the Marine Division for its expanding role in the Polaris Program.

• **United Aircraft Corp. . . .** Hamilton Standard Division has established an Advanced Product Planning Group to discover product possibilities for the company in or out of the aircraft field.

• **Westinghouse Electric Corp.** has elected Mark W. Cresap, Jr., President and Chief Executive Officer, and Gwilym A. Price, Chairman of the Board. The company also eliminated the policy and finance committee in an effort to provide more centralized executive control. . . . Defense Products Group Headquarters has announced plans for continuing collaboration with Rolls-Royce Ltd. in the aircraft engine field.

IAS News

IAS Sections

Baltimore Section

Two Classified Meetings Held

Army research and development, with particular emphasis on limited warfare requirements, was the subject of **Major Gen. Robert J. Wood's** talk at the classified March meeting. General Wood is Deputy Chief of R&D, Department of the Army. His speech was augmented with slides and films.

A classified February meeting was held at Bendix Radio Division in Towson, Md., at which **Clayton Clark** spoke on the X-15 program. Mr. Clark is Weapons Systems Representative, Plans and Programs, North American Aviation, Inc.

LEONARD ATRAN, *Secretary*

Detroit Section

IAS Members, 2 Other Groups Sponsor Space Law Forum

A Space Law Forum and dinner were held at the Engineering Society of Detroit on March 12 under joint sponsorship of the Detroit IAS Section, American Rocket Society, and Michigan State Bar Association. James A. Hill, of the Section, was most active in organizing the program.

A panel moderated by **Andrew G. Haley,** President of the International Astronautical Federation, discussed **"The Techno-Legal Aspects of Space Exploration."** The audience heard outlined the many problems of legal control of missiles, re-entry vehicles, and orbiting satellites, and some projected proposals for anticipated changes in international and comparative law to accommodate and control such vehicles.

Representing the sciences were two members of Chrysler Corp.'s Missile Division—Lovell Lawrence, Jr., Chief Engineer, Weapons Systems, Advanced Projects Organization, and Gordon Coates, Group Supervisor, Trajectory Guidance Analysis.

Representing the Bar Association's Space Law Subcommittee were G. Vernon Leopold, Chairman, and Allison L. Scafuri.

Dinner speaker was **Edwin A. Nielson,** Assistant Chief Engineer, Design Branch, Engineering Office, of Chrysler's Missile Division.

WILLIAM SPREITZER, *Secretary*

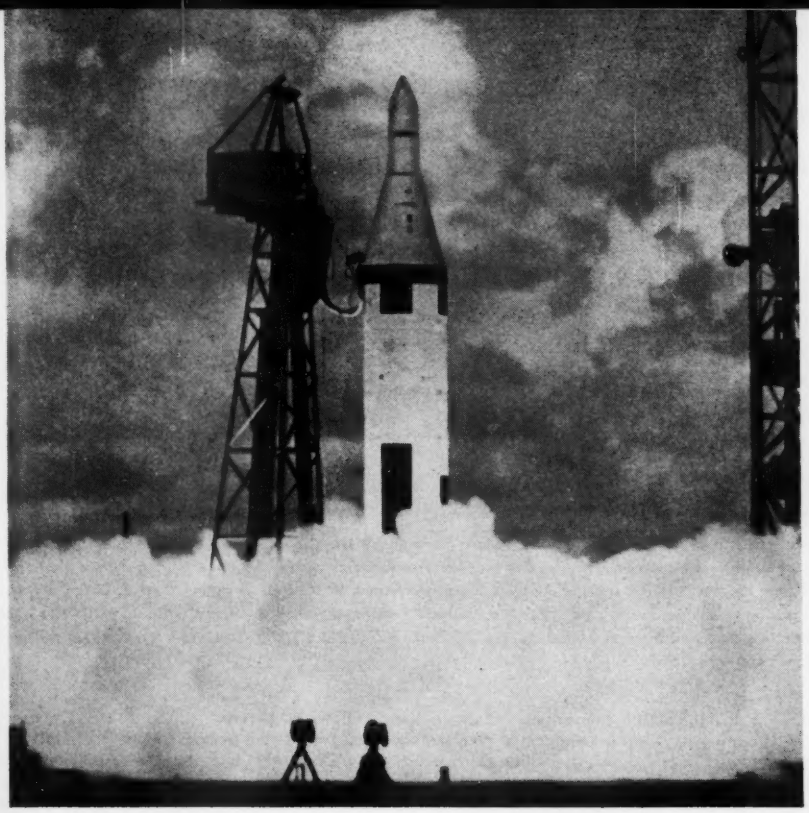
Mr. John Higginson, of Thiokol Chemical Corp., addresses the first dinner meeting of the Great Salt Lake Section. Colonel Leigh Hunt, USAF, Chairman, presided over the meeting. Other officers are: Vice-Chairman Jean Mayers, Engineering Section Head, Sperry Utah Lab.; Secretary Karl L. Koerner, Assistant Professor, University of Utah; Treasurer Richard Laucher, Engineering Manager, Marquardt Aircraft.

Great Salt Lake Section

First Dinner Meeting Held March 27

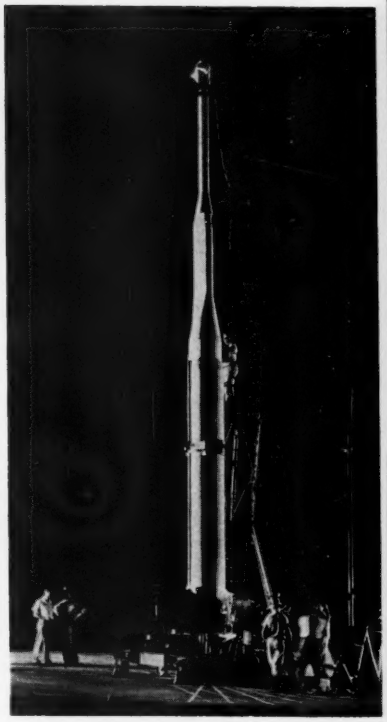
The first dinner meeting was held March 27, at Hill AFB, Utah, where members and guests heard **John Higginson,** General Manager of the Utah Division of Thiokol Corp.

After giving a brief history of the solid-propellant rocket engine, Mr. Higginson discussed certain features which would give the best operating efficiency, and then described construction of the rocket engine and how the propellant is cast. He followed his talk with a film which illustrated the instrumentation and test-



(left) Navy Polaris AX-1 flight test vehicle at beginning of launch. Lockheed's Polaris fleet ballistic missile is more than a year ahead of original schedule.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.



STRUCTURES AND DESIGN

Expanding the Frontiers of Space Technology

Design is a challenging and growing field at Lockheed dealing with varying phases of mechanical, electrical and structural problems.

Some of the most difficult structure problems in the missile industry were successfully met by Lockheed design engineers for the Navy Polaris IRBM, where the unique launching environment—water—aggravates the normal critical missile requirements of strength minus weight.

Major emphasis in structures concerns the design of re-entry bodies, thrust termination, and underwater launching devices. Other significant work has been accomplished in the mechanical design of vehicle frames, flight controls, hydraulic, ignition and separation systems; and in the electrical design of equipment for test, check out, arming and fusing, guidance, and telemetry.

As systems manager for such major, long-term projects as the Navy Polaris IRBM; Army Kingfisher and Air Force Q-5 and X-7 and other important programs, Lockheed engineers and scientists face a double challenge – to improve existing designs and devise solutions to new problems.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research and development programs. Write: Research and Development Staff, Dept. F-11, 962 W. El Camino Real, Sunnyvale, California. U.S. Citizenship required.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed / **MISSILES AND SPACE DIVISION**

Weapons Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; and Air Force Q-5 and X-7.

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIF.
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII

Major Gen. Marvin C. Demler, USAF, is shown (*left*) during his address on April 9 before the Institute's New York Section. General Demler, Director of Research and Development, Office of Deputy Chief of Staff—Development, USAF, spoke on "Air Force Research and Development Management in the Aero/-Space Age." His talk, published in condensed form as an article in this issue, climaxed the Section's tour of Kearfott Company Plant 1, Little Falls, N.J. The Company's welcome was extended (*center photo*) by Charles Berry, Assistant to the President. *Right*, a view of the head table shows (*left to right*) Richard Bowman, Section Advisory Board Member, Mrs. Bowman, General Demler, Robert L. Gustafson, New York Section Chairman, Mr. Berry, Mrs. Ruland M. Woodham, and Mr. Woodham, who is Section Secretary-Treasurer.

ing of the world's largest solid-propellant engine.

Colonel Leigh Hunt, USAF, Section Chairman, was master of ceremonies, and for this first meeting an entertaining program was provided. Besides Mr. Higginson, the main speaker, there were Major Gen. P. H. Robey, Commander of Hill AFB, who extended a warm welcome to the group, and Jean Mayers, Vice-Chairman, who issued a standing invitation to all to attend subsequent meetings.

KARL L. KOERNER, *Secretary*

Hagerstown Section

Three From Fairchild Speak on Quality Control

Types of testing and the devices used were discussed at the March meeting by three speakers from Fairchild Engine and Airplane Corporation's Quality Control Department.

J. C. Maycock discussed the various types of testing done by the Quality Control Department—reliability, preproduction or qualification, acceptance, environmental, and proof testing. Equipment available for environmental testing includes the altitude chamber, vibration tester, accelerator, and radio noise test facility. The high-pressure pneumatic machine was given as an example of proof testing equipment.

E. M. Marcus described some of the nondestructive tests made in the manufacturing inspection area. Radiography, he said, was the first form of nondestructive testing; later, for inspecting ferromagnetic materials, electromagnetism or magnaflux is used. Dye penetration and fluorescent penetration with ultraviolet rays is used for nonferrous materials for surface and visual types of inspection. Eddy current testing is used for the determination of the secondary characteristics of materials. Conductivity readings are used to obtain tensile, yield, and ultimate stresses, and also hardness characteristics.

J. J. Hughes described some of the equipment used for nondestructive testing made in the laboratory. The direct reading spectrograph is used for analyzing the material make-up of sheets, beams, bolts, etc. Hydrogen analyses and fatigue tests are made on titanium-alloy fasteners. He also talked about the various uses of fluoroscopic and x-ray testing.

All three speakers showed slides to amplify their presentations.

E. L. HARKLEROAD, *Secretary*

Omaha Section

New Section Elects Officers

The first permanent officers elected are Col. A. F. Meyer, Chief, Preventive Medicine Branch, Professional Division, Surgeon's Office, Chairman; Dr. R. H. Smith, Chief Operations Analysis, Vice-Chairman; M. D. Taylor, Senior Service Representative, Boeing Airplane Co., Secretary; and Major W. G. Hynds, Aircraft Branch, Requirements Division, Directorate of Operations, Treasurer.

Appointed to the Governing Board are Major Gen. C. B. Westover, Director of Plans; Major Gen. J. V. Edmundson, Director of Operations; Col. R. N. Smith, Director of Intelligence; Col. A. A. Arnhym, Assistant to CINC SAC; Dr. M. D. Schwartz, Chief, Weapon Systems Team, Operations Analysis; and R. E. Bateman, Senior Engineering Representative, Boeing Airplane Co.

M. D. TAYLOR, *Secretary*

San Francisco Section

McIver Outlines Plans by United Air Lines for DC-8

Robert McIver, 1958 Section Chairman, spoke at the March meeting on preparations for incorporating the DC-8 into UAL flight schedules. He described these transports as having introduced a new era of transportation to the public and a completely new aircraft to the pilot.

Not only has the jet engine replaced the reciprocating engine, he noted, but the swept wing has replaced the familiar straight wing. Significance of the transition was emphasized by geometry and performance figures. A color film showed the "8" in flight and on the ground and some views of the interior, and indicated some handling characteristics.

The first DC-8 flew early last year, and flight tests and certification are continuing with the first few airplanes. UAL expects to receive 20 between now and the end of this year; in all, 40 have been ordered at a cost of $275 million.

The speaker declared that the captain of the new airplane can no longer be a "one-man band" and face emergencies alone. Rigorous training, he said, is in progress with the aid of a new flight simulator built by Link Aviation, Inc.

An actual, completely instrumented nose section and crew compartment is employed in the simulation. In addition to the usual functions of a trainer, the compartment will pitch and roll on command of the pilot or instructor programing the particular flight problem. A projected motion-view of an airport provides landing realism. All crews will have at least 20 hours in the simulator before flight check-outs.

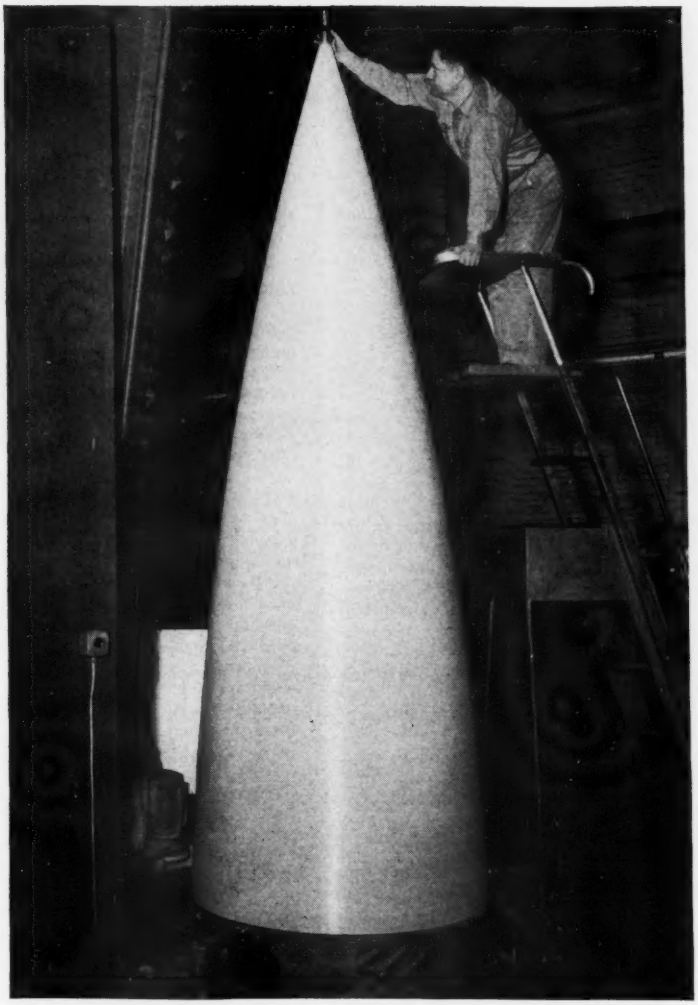
Slides showed the audience components of the simulator. A question-answer period closed the meeting.

N. R. BERGRUN, *Secretary*

South Florida Section

V-P—Engineering Discusses Smith Super 26

The business aircraft market in general and the Smith Super 26 in particular were discussed by **Ed E. Brush,** Vice-President—Engineering, L. B. Smith Aircraft Crop., at the March meeting. The Super 26 is a two-engine, seven-passenger, pressurized cabin, executive airplane.



NEW—the world's biggest filament-wound fiberglass radome!

Here it is — twelve feet high, four feet in diameter — the largest filament-wound fiberglass radome ever made. This huge form was produced by a special winding process—product of Kidde engineering knowledge and research — which results in an extremely high strength-to-weight ratio, plus a maximum in physical and electrical uniformity. Furthermore, this Kidde continuous-winding process, plastic reinforced by fiberglass, permits the construction of fiberglass shapes and forms which were either difficult or impossible to fabricate by previous methods.

Walter Kidde & Company has available complete facilities and personnel for the development, testing and production of fiberglass forms. If you have a problem in this area — write Kidde today. We've solved some pretty tough ones in the last thirty years!

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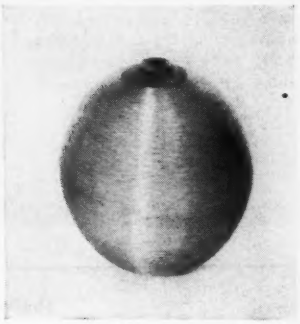
FIBERGLASS FORMS ARE A KIDDE SPECIALTY!

Thanks to Kidde's continuous winding process, a new field of fiberglass forms is now open to aviation engineers. Structural tubing, pressure vessels can now be made stronger than steel with half its weight!



For the engineer interested in the field of pneumatics, filament-wound fiberglass spheres offer the solution to many problems. Available in capacities of from 50 to 2500 cubic inches these spheres can withstand pressures up to 5000 psi.

Missile rocket motor cases, torpedo bodies and missile radomes are but a few of the forms which Kidde can fabricate from high-strength, low-weight fiberglass, capable of withstanding temperatures as high as 1000°F. for short periods of time.

Mr. Brush stated that the CAA (now the FAA) was caught unprepared by the demand for corporate aircraft by business organizations. He described the DC-3 Ledestar, Learstar, and Beech 18 as obsolete. The PV-1, PV-2, B-25, and B-26 have been released as surplus by the military services for purchase by civilians. These aircraft have been and are being converted to executive use. He said that although a few PV-1's and PV-2's have been pressurized, the L. B. Smith conversion of the Douglas B-26 incorporates complete pressurization of the cockpit and cabin.

Mr. Brush said that some of the reasons L. B. Smith Aircraft chose the B-26 as the airplane to convert were (1) the NACA had conducted a thorough study of the aerodynamic characteristics of the B-26, (2) over 600 B-26 aircraft were available, and (3) the low purchase price from the military of $2,000–$4,000.

The head room in the Super 26 cabin has been increased to 6 ft., 2 in., the cockpit rearranged, the nose extended 40 in. to accommodate radar and baggage, and the tail extended aft 6 ft. A rigid frame design replaces the center wing spars to provide more cabin area. The drawing that was shown to those in attendance located the galley and lavatory between the wing spars. The added fuel capacity furnished by the wing tip tanks (160 gal. per tip tank) increases the capacity to 1,530 gal. and the range to 3,000 miles.

The 35,000 lbs. gross weight has been maintained with the 350 m.p.h. cruising speed. Mr. Brush, therefore, stated that the Smith Super 26 is considered the fastest reciprocating engine executive airplane flying today. He also said that the price of the Super 26 is $350,000 less interior and electronics, and concluded with comparisons of the Super 26 with the Gulfstream, Jet Star, and F-27 to show that the Super 26 definitely has a place in the business aircraft market.

ANDREW C. MCDERMOTT, *Secretary*

Tullahoma Section

Two from G-E Give Classified Discussion

Speakers **Dr. J. D. Stewart** and **A. Lengyel,** of G-E's Missile and Space Vehicle Department, gave a classified discussion at the April 1 meeting on the use of aerothermodynamic test data toward the design of a ballistic nose cone vehicle. The prediction of the thermodynamic and aerodynamic performance of several nose cones from the data obtained in ground test facilities such as hot-shot wind tunnels and shock tubes was compared with flight-test data. Also stated was the importance of large-scale transonic testing to investigate dynamic and static stability of a ballistic nose cone shape since this is the Mach regime where such performance is most unpredictable.

This meeting was held in the A&E Conference Room at Arnold Engineering Development Center.

MILTON W. DAVIS, *Secretary*

Tulsa Section

Boeing Aerodynamics Engineer Talks About Practical Applications

Low-speed, high-lift BLC for high-performance aircraft was discussed in a talk on "**Some Aspects of Blowing, Boundary-Layer Control in Practical Applications**" by **Richard E. Wallace** of Boeing Airplane Co., Wichita, Kan., at the March 18 meeting.

The discussion was primarily concerned with the application of blowing on the wing boundary layer for the purpose of increasing maximum lift. Mr. Wallace reviewed the theory of this type of BLC and discussed its applications and limitations. Comparing blowing to suction, he said that for most applications, the relative simplicity of blowing more than made up for its lower aerodynamic efficiency. He concluded that most current and future airplane designs would benefit from the use of such methods.

ALLAN M. MCCASKILL, *Secretary*

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Sherman M. Fairchild Publication Fund Papers (*Order by number from IAS*)

No.		Member	Nonmem.
FF-22	Methods of Boundary-Layer Control for Postponing and Alleviating Buffeting and Other Effects of Shock-Induced Separation—H. H. Pearcey and C. M. Stuart.	$1.50	$3.00
FF-21	Rocket Propulsion Systems for Interplanetary Flight—George P. Sutton, 1959 Minta Martin Lecture.	1.00	2.00
FF-20	Supersonic Transports Proceedings (Papers and Discussions presented at IAS 27th Annual Mtg. Session).	1.00	2.00
FF-19	Combustion—An Aeronautical Science—H. W. Emmons, 1958 Minta Martin Lecture.	0.75	1.25
FF-18	On the Main Spray Generated by Planing Surfaces—Daniel Savitsky and John P. Breslin.	0.75	1.25
FF-17	Atomic Reactors (a Symposium).	1.25	1.75
FF-16	Inertial Guidance—W. Wrigley, R. B. Woodbury, and J. Hovorka.	0.75	1.25
FF-14	Engineering Management Philosophies (a Symposium).	0.50	1.00
FF-12	Transonic Testing Techniques (a Symposium).	1.85	2.50
FF-11	Wetted Area and Center of Pressure of Planing Surfaces at Very Low Speed Coefficients—Experimental Towing Tank, Stevens Inst. of Tech.	1.20	1.60
FF-10	Improved Solutions of the Faulkner and Skan Boundary-Layer Equation—A. M. O. Smith.	0.75	1.25
FF-9	A Hydrodynamic Study of the Chines-Dry Planing Body—Experimental Towing Tank, Stevens Inst. of Tech.	1.20	1.60
FF-7	Natural Flight and Related Aeronautics—James L. G. Fitz Patrick.	2.65	3.50
FF-4	Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders—F. K. Teichmann and Chi-Teh Wang.	0.50	0.85
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Inst. of Tech.	1.20	1.60

No.		Member	Nonmem.
AHS-1	Helicopter Flight Research at NACA, Langley—Jack P. Reeder.	$0.35	$0.75
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	0.75	1.25
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Dead-Rise Surface—Experimental Towing Tank, Stevens Inst. of Tech.	1.20	1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Exp. Towing Tank, Stevens Inst. of Tech.	1.20	1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Inst. of Tech.	0.75	1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Exp. Towing Tank, Stevens Inst. Tech.	1.20	1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Inst. of Tech.	0.75	1.00
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman.	0.75	1.00
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	0.35	0.50
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	1.85	2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	0.60	0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	2.65	3.50
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen.	0.75	1.00

Jewels by Janitrol

If you are concerned with utilization, distribution, and control of high temperature, high pressure air for canopy seal, tank pressurization, fuel transfer, or any other interesting aircraft or missile application, this picture will interest you.

It shows an important facet of Janitrol's capabilities in the design and production of precision valves whose refinements and tolerances call for a jeweler's approach. The large family of Janitrol valves offers convincing evidence of our exceptional problem solving abilities in a field where reliability requirements are constantly being raised.

A complete picture of our capabilities is presented in a new brochure "Janitrol Resources." For your copy ask your nearest Janitrol engineering representative, or write: Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio, BRoadway 6-3561. Also: Ft. Worth, WAlnut 6-3386; Hollywood, HOllywood 3-6861; Washington, D. C., OLiver 4-2171; Philadelphia, MIdway 2-6342.

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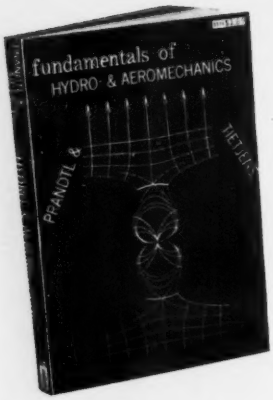
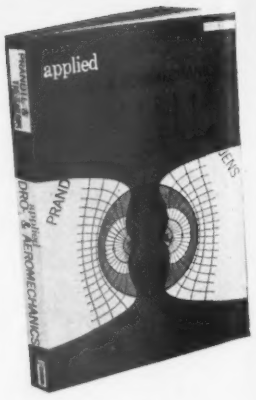


UNABRIDGED REPRINTING OF PRANDTL & TIETJENS'S BASIC WORK ON HYDRO-DYNAMICS AND AERO-DYNAMICS . . . NOW ONLY $1.85 PER VOLUME



FUNDAMENTALS OF HYDRO- AND AEROMECHANICS by L. Prandtl and O. G. Tietjens

This well-known study is an expansion by O. G. Tietjens of lectures delivered by Professor Prandtl at the Kaiser Wilhelm Institute for Flow Research. It not only applies Prandtl methods of organization and presentation; it also contains many of Prandtl's ideas and experimental results that are not easily obtainable elsewhere.

This book is devoted to the theory of equilibrium of liquids and gases, which it develops and discusses lucidly in terms of fundamental concepts. While presentation is physical rather than mathematical, proofs are relatively rigorous and use vector methods to a large extent. Stress is upon theory, rather than practical application.

The contents include airfoil theory, meteorology, free balloons, fluid mechanics, and similar topics. The authors apply the concept of boundary layers and vortices to synthesize aspects of theoretical studies with observable phenomena. Effects of viscosity and compressibility are continually born in mind. The authors analyze thoroughly such topics as statics of liquids and gases, stability, pressure equation, static lift, surface tension, kinematics of liquids and gases, acceleration of a fluid particle, dynamics of nonviscous fluids, the Eulerian equation, potential motion, 2-dimensional potential motion, vortex motion, theorems of energy and momentum, and similar material.

"Useful to give an excellent slant on practical uses of vector analysis" NATURE, An Engineering Society Monograph, 1934. 186 figures, 295 pp.

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AERODYNAMICS

Introduction to the Theory of Compressible Flow. Shih-I Pai. Princeton, N.J., D. Van Nostrand Co., Inc., 1959. 385 pp., diagrs. $9.75.

The fundamentals of the theory of compressible flow are treated in this book—from basic assumptions and formulations of theory to various methods of solving the problems involved. Based on lecture notes which the author uses in a course in advanced aerodynamics in the Aeronautical Engineering Department, University of Maryland, the book has chapters devoted to the physical properties of gases; the theory of compressible flow of inviscid fluids, covering both steady and nonsteady flow; transonic, hypersonic, and rotational flow; shock waves in a real gas; diabatic flow; and the essential points of a viscous compressible fluid, including the effect of chemical reaction and electromagnetic forces.

Dynamics of Flight: Stability and Control. Bernard Etkin. New York, John Wiley & Sons, Inc., 1959. 519 pp., illus., diagrs. $15.

Emphasizing the fundamental aspects, while at the same time bringing in applications and typical results, this book treats the underlying principles and essential techniques of the dynamics of flight. Incorporating recent developments, the author covers static and dynamic stability, transient and frequency response, feedback systems and automatic controls, dynamics of missiles, machine computation (analog and digital), and mathematical aids. The work offers material on inverse problems and on flight through turbulent air. Automatic control theory is approached from the aeronautical engineer's viewpoint, and machine computation is treated from the standpoint of the machine user, not the computing specialist. Many completely worked-out numerical examples, with graphs of the results, are utilized.

The subject matter has been taught by the author for some 15 years at the University of Toronto.

A Textbook of Fluid Mechanics for Engineering Students. J. R. D. Francis. London, Edward Arnold (Publishers) Ltd.; New York, St. Martin's Press, 1958. 332 pp., illus., diagrs., tables. $6.50.

In an attempt to make this textbook readily intelligible to undergraduate engineers, the author has omitted many rigid proofs of mathematical formulas and considerably simplified many others. Also, detailed tables of experimental data have been avoided as far as possible. On the other hand, much attention is given to the limitations of theoretically derived equations since the author considers that, to the engineer, the practical limitations of a theory are of more interest than a perfect proof.

Chapter 9, entitled *Compressibility in Moving Fluids—Gas Flow*, was contributed by G. Jackson, Lecturer in Aeronautics, Imperial College of Science and Technology, University of London, where Francis is Lecturer in Civil Engineering.

AERONAUTICS, GENERAL

The Aircraft Year Book, 1959. 40th Annual Ed. Official Publication of the Aircraft Industries Association, Inc. Washington, American Aviation Publications, Inc., 1959. 486 pp., illus., diagrs. $6.00.

Contents: Aviation Events. The Industry: Airframe, Engine, and Missile Manufacturers; Systems and Components Manufacturers. Military Aviation. Research and Development. Civil Aviation: The Airlines; Helicopters; General Aviation. Government and Aviation. Aircraft in Production. Engines in Production. Missiles. United States Chronology. 1958 Day by Day Chronology. Official Records. Bibliography (U.S. books for 1958). Index.

AVIATION AND SPACE MEDICINE

Reports on Space Medicine—1958. Randolph AFB, Texas, Air University, School of Aviation Medicine, USAF, February, 1959. 103 pp., illus., diagrs., tables.

A collection of reprints. *Contents*: Human Performance in the Space Travel Environment, G. T. Hauty. Supersonic and Hypersonic Human Flight, J. E. Ward, S. J. Gerathewohl, and G. R. Steinkamp. Human Engineering of the Sealed Space Cabin, J. E. Ward and G. R. Steinkamp. Fatigue, Confinement, and Proficiency Decrement, G. T. Hauty and R. B. Payne. The Feasibility of Recycling Human Urine for Utilization in a Closed Ecological System, W. R. Hawkins. Space Cabin Requirements as Seen by Subjects in the Space Cabin Simulator, W. R. Hawkins and G. T. Hauty. Weightlessness—The Problem and the Air Force Research Program, S. J. Gerathewohl.

COMPUTERS

Proceedings of the Fifth Annual Computer Applications Symposium, October 29–30, 1958. Sponsored by Armour Research Foundation, Illinois Institute of Technology. Chicago, The Institute, 1959. 153 pp., illus., diagrs. $3.00.

Contents: Operations Research and the Automation of Banking Procedures, R. A. Byerly. Information Systems Modernization in the Air Materiel Command, D. E. Elleet. Utilization of Computers for Information Retrieval, A. Opler. Problems and Prospects of Data-Processing for Defense, C. A. Phillips. An Integrated Data-Processing System with Remote Input and Output, R. D. Whisler. The Role of Character-Recognition Devices in Data-Processing Systems, R. L. Harrell. Input-Output—Key or Bottleneck?, R. D. Elbourn. Scientific Uses of a Medium-Scale Computer with Extensive Accessory Features, R. A. Haertle. The Design of Optimum Systems, R. R. Brown. Computer Applications in the Numerical Control of Machine Tools, R. B. Clegg. Frontiers in Computer Technology, R. W. Hamming. Computer Sharing by a Group of Consulting Engineering Firms, E. M. Chastain and J. C. McCall. Current Developments in Computer Programming Techniques, F. Way III. The Future of Automatic Programming, W. F. Bauer.

DIRECTORIES

Aviation Directory of Canada, 1959. Toronto, Canada, Farm Equipment Publishing Co., Ltd., 1959. 196 pp., illus., diagrs. $5.00.

Includes brief Who's Who section and a Glossary of Abbreviations.

ELECTRONICS

Conductance Design of Active Circuits. Keats A. Pullen, Jr. New York, John F. Rider Publisher, Inc., 1959. 330 pp., diagrs., tables. $9.95.

In this textbook on the use of conductance curves in the design of tube and transistor circuits, discussions center on the design of circuits for use with active devices in terms of a combination of their small-signal and static or d.c. behavior. The relations of the circuit to the device and the method of getting stable and reliable operation from the combination is clearly shown. Also, a review is given of the physical principles underlying the design of circuits using nonlinear devices whereby the reader may more easily proceed to problems of increasing complexity. Other pertinent items include a system of design for a wide variety of circuits; a system applicable, with minor changes, to both transistors and tubes; methods of checking limits, of providing reliable operation, and of reducing the adjustment time required for improvement of the effectiveness of design.

The author is a member of the Scientific Staff, Ballistic Research Laboratories, Aberdeen Proving Ground.

Semiconductors. Edited by N. B. Hannay. (American Chemical Society Monograph No. 140.) New York, Reinhold Publishing Corp., 1959. 767 pp., illus., diagrs., tables. $15.

This reference work on the physical chemistry and fundamental physics of semiconductors gives detailed analyses of important materials, with emphasis throughout on basic principles and phenomena.

The contributors are all leaders in semiconductor research; Hannay is with Bell Telephone Laboratories, Murray Hill, N.J.

Contents: (1) Semiconductor Principles, N. B. Hannay. (2) Survey of Semiconductor Chemistry, J. J. Lander. (3) Semiconductor Crystal Growing, M. Tanenbaum. (4) Control of Composition in Semiconductors by Freezing Methods, C. D. Thurmond. (5) Defect Interactions in Semiconductors, C. S. Fuller. (6) Diffusion Processes in Germanium and Silicon, H. Reiss and C. S. Fuller. (7) The Chemistry of Some Compound Semiconductors, D. G. Thomas. (8) Group IV Semiconductors, T. H. Geballe. (9) Properties of Some Covalent Semiconductors, J. M. Whelan. (10) Infrared Absorption of Semiconductors, H. J. Hrostowski. (11) Recombination and Trapping, R. G. Shulman. (12) Effect of Imperfections on Germanium and Silicon, J. N. Hobstetter. (13) Semiconducting Properties of Some Oxides and Sulfides, A. R. Hutson. (14) Oxides of the 3*d* Transition Metals, F. J. Morin. (15) Organic Semiconductors, C. G. B. Garrett. (16) Semiconductor Surfaces, J. T. Law. (17) Semiconductor Electrodes, J. F. Dewald. Index.

Fundamentals of Radio Telemetry. Marvin Tepper. New York, John F. Rider Publisher, Inc., 1959. 116 pp., illus., diagrs., tables. $2.95.

The author has written this book with the idea of explaining the overall picture of telemetry. No assumption is made that the reader has been exposed to this field. Outside of a basic knowledge of electronics, no other background is necessary to understand this text.

Contents: Introduction to Telemetry. Telemetry Inside the Missile. Multiplexing. The Telemetry Receiving Station. Recovering and Recording the Data. Digital Techniques in Telemetry. Telemetry Data Reduction. Satellite Telemetry. Bibiliography. Appendix I: Telemetry Standards for Guided Missiles. Appendix II: Magnetic Recorder/Reproducer Standards. Index.

LAWS AND REGULATIONS

Civil Air Regulations and Flight Standards for Pilots. 21st Ed. Los Angeles, Aero Publishers, Inc., 1959. 160 pp., diagrs., tables. $2.50.

MATERIALS

Material Properties Handbook; Vol. I, Aluminium Alloys. NATO AGARD. Collected and Prepared by the Technical Department, The Royal Aeronautical Society, London, 1958. 143 pp., tables; loose-leaf. Distributed in United States by NASA, Washington.

The present *Handbook* results from an international cooperative effort to make information on the properties of aircraft materials produced in various NATO countries easily accessible in consistent and systematic form. The AGARD Panel on Structures and Materials (Frank R. Thurston, Chairman) produced the *Handbook* in association with the Production and Logistics Division of the NATO International Secretariat. The basic data from which the charts have been prepared were provided by nationally appointed representatives of the various NATO countries which, in the first issue, include Canada, France, Italy, the United Kingdom, and the United States.

This first volume deals with those aluminum alloys which are most widely used structurally in aircraft of the NATO nations. Alloys which are used only for castings or for rivets have not been included. The data are divided into *National Sections*, each section dealing with the alloys produced by one country and for each distinct alloy there is a set of sheets which give information on its physical and mechanical properties, both at room and elevated temperatures. Preceding these sheets are *Introductory Notes* which give general information and amplify such points as the designations and specifications of the alloys, heat treatment, cladding thicknesses of plates, testing procedures, and other information. The data are presented in tabular rather than graphical form, and any information that is nonstandard, or any points that need stressing, are dealt with in footnotes. The book is in loose-leaf form, and charts will be reissued from time to time as additional or improved data become available.

Creep of Engineering Materials. Iain Finnie and William R. Heller. New York, McGraw-Hill Book Co., Inc., 1959. 341 pp., diagrs., tables. $11.50

This is a comprehensive treatment of the creep of materials, which discusses design for creep conditions in thorough detail to aid in formulating and solving engineering problems. Details and illustrations are given for such topics as creep testing; measurement of creep variable such as temperature, strain, and load; mechanisms involved in the creep of metals and nonmetals; stress analysis under creep conditions; sources of creep data, factors in choosing a design stress; and creep problems that occur in specific applications, as with gas turbines, aircraft, and missile structures.

The authors are both with the Shell Development Company.

The Physical Metallurgy of Magnesium and Its Alloys. G. V. Raynor. New York, London,

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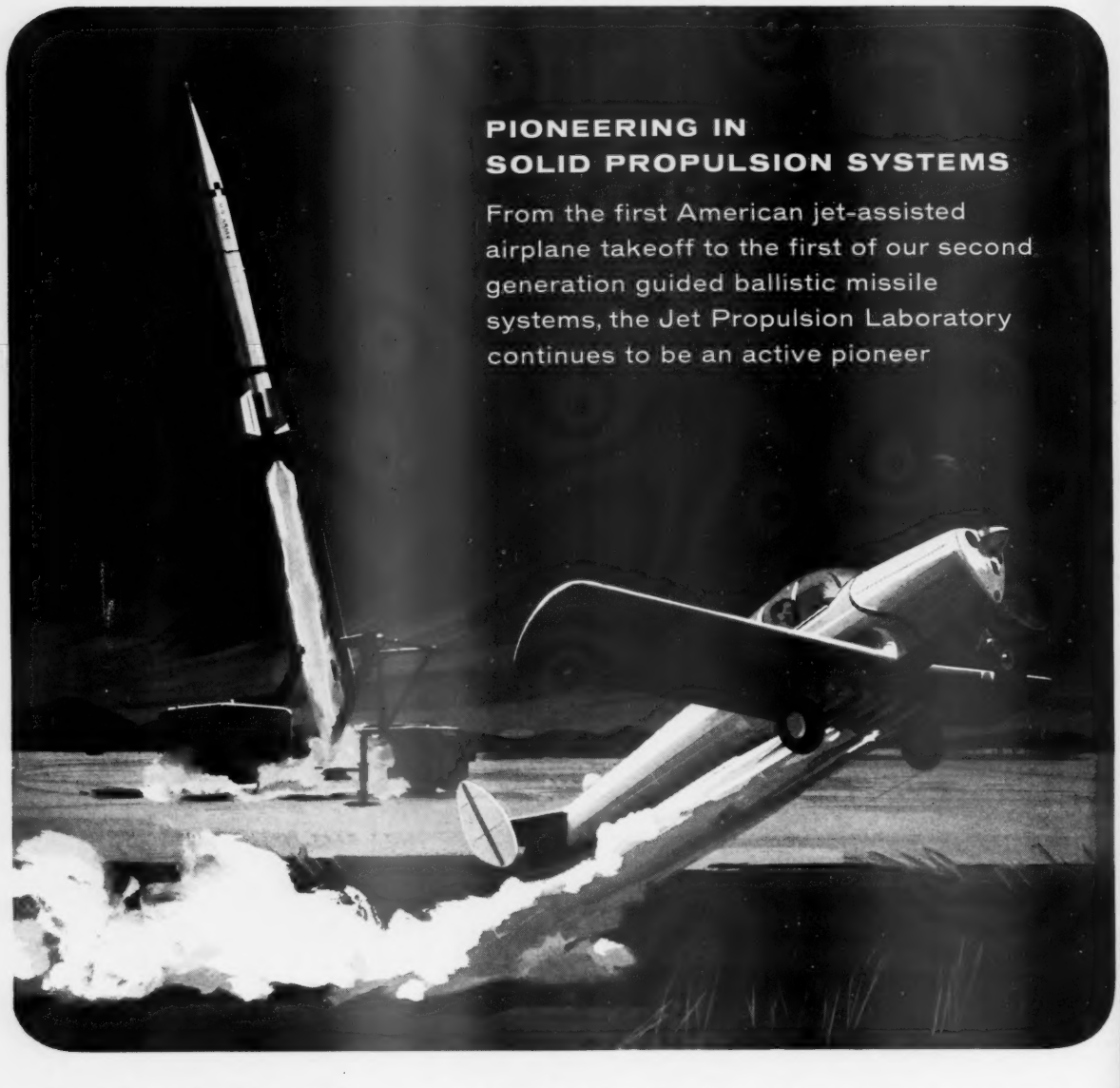
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Pergamon Press, 1959. 531 pp., diagrs., tables. $12.50.

Based partly on lectures to fourth-year college students, this treatment presents a selective picture of the physical and theoretical background to the technology of magnesium and its alloys. The first part of the book deals with the fundamental nature of magnesium, its electronic constitution, and the effects of alloying. The theories of solid solubility limits, liquidus curves, intermetallic compound formation, and lattice spacing variations are detailed, and general interrelationships between the intermediate phases observed are stressed. Essential deformational characteristics of single crystals and polycrystalline aggregates are outlined. The second part describes and discusses the alloy systems formed by magnesium, with the stress laid on those of present or potential importance.

Professor Raynor is Feeney Professor of Physical Metallurgy, Department of Physical Metallurgy, Birmingham University.

Filler Metals for Joining. Orville T. Barnett. New York, Reinhold Publishing Corp., 1959. 244 pp., illus., diagrs., tables. $7.00.

This convenient reference volume for welding engineers and welders, designers, and purchasing agents summarizes industrial practice in selecting the proper filler metal for any metal joining situation. Covering ferrous and nonferrous joining metals, the book discusses welding, brazing, and soldering, with major emphasis on products for manual and automatic welding. Available materials are discussed in terms of applicability, mechanical properties, and degree of availability. The principal chapters are devoted to arc welding electrodes; automatic welding of mild and low alloy steels, which discusses materials in an area where no specifications yet exist; iron powder electrodes; the latest developments in nonferrous metals; surfacing; and tungsten electrodes.

Mr. Barnett is Assistant Manager, Metals Research Division, Armour Research Foundation, Illinois Institute of Technology.

MATHEMATICS

Convex Surfaces. Herbert Busemann. New York, Interscience Publishers, Inc., 1958. 196 pp. $6.00.

Extrinsic and intrinsic geometry, applications of the Brunn-Minkowski theory, and the realization of intrinsic metrics are the subjects treated. The book is the result of a group of lectures given by the author in Seattle in 1956 at the Summer Institute for Differential Geometry in the Large. Prerequisites for the various parts vary, but in general include a thorough familiarity with the classical differential geometry of surfaces and some knowledge of eigenvalues of quadratic forms and of integral equations; the theory of real variables, in particular of set functions; and the theory of elliptic partial differential equations.

MECHANICS

Proceedings of the Third U.S. National Congress of Applied Mechanics Held at Brown University, Providence, Rhode Island, June 11–14, 1958. New York, The American Society of Mechanical Engineers, 1958. 864 pp., illus., diagrs., tables. $20.

Contents: General Lectures. Linear Thermodynamics and the Mechanics of Solids, M. A. Biot. Some Aspects of Boundary Layer Flow in Subsonic and Supersonic Air Streams, H. L. Dryden. A Survey of the Theories of Creep Buckling, N. J. Hoff. Rotationally Symmetric Problems in the Theory of Thin Elastic Shells, E. Reissner.

Technical Papers: *Dynamics, Vibrations, Elastic Waves.* The Solution of Duffing's Equation for the Softening Spring System Using the Ritz-Galerkin Method with a Three Term Approximation, C. P. Atkinson and C. P. Bourne. The Response of Elastic Spherical Shells to Spherically Symmetric Internal Blast Loading, W. E. Baker and F. J. Allen. On Elastic Impacts of Spheres on Long Rods, C. S. Barton, E. G. Volterra, and S. J. Citron. Vibration Analysis by the Root Locus Method, R H. Cannon, Jr. Whirling of a Heavy Chain, T. K. Caughey. Energy Dissipation in Longitudinal Vibration, C. S. Chang. Transient Motion in Mechanical Wave-Filters, J. N. Christiansen. Vibration of Rectangular Plates and Plate Systems, E. H. Dill and K. S. Pister. Electronic Computer Simulation of a System with a "Trilinear" Restoring Function, M. Dost and C. P. Atkinson. Response of Tall Buildings to Random Earthquakes, A. C. Eringen. Stresses in Curved Beams Due to Transverse Impact, W. Goldsmith and G. W. Norris, Jr. Flexural Vibrations of a Thick Walled Circular Cylinder, J. E. Greenspon. Vibrations of a Uniform, Rotating Beam with Tip Mass, G. Handelman, W. Boyce, and H. Cohen. Flexural Vibration of Orthogonally Stiffened Circular and Elliptical Plates, W. H. Hoppmann II. Effect of Rotary Inertia and Shear on the Vibration of Beams Treated by the Approximate Methods of Ritz and Galerkin, T. C. Huang. Propagation of Abrupt Circular Wave Fronts in Elastic Sheets and Plates, W. E. Jahsman. A Simple Mechanical Method for Measuring the Reflected Impulse of Air Blast Waves, O. T. Johnson, W. C. Olson, and J. D. Patterson II. Thermally Induced Elastic Wave Progagation in Slender Bars, J. E. Michaels. On the Use of Approximate Theories of an Elastic Rod in Problems of Longitudinal

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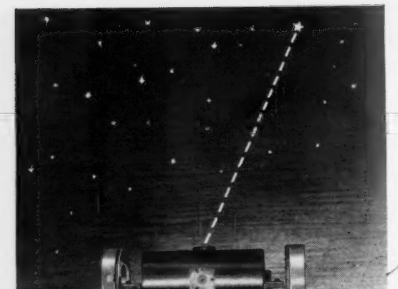

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An Introduction to Advanced Dynamics. S. W. McCuskey. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959. 264 pp., illus. $8.50.

The purpose of this introductory text is to familiarize advanced undergraduate students in science and mathematics with some of the ideas of classical dynamics not ordinarily treated in elementary mechanics. Only certain aspects of the classical dynamics of particles and of rigid-body motion are discussed, with the emphasis placed on underlying principles, as illustrated by a few familiar applications. Although courses in differential equations and in advanced calculus are considered necessary prerequisites, a previous knowledge of matrix algebra is not.

The author is Chairman, Department of Mathematics, Case Institute of Technology.

PHYSICS

Physical Laws and Effects. C. F. Hix, Jr., and R. P. Alley. New York, John Wiley & Sons, Inc., 1958. 291 pp., diagrs., tables. $7.95.

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The authors are, respectively, with the Missile and Space Vehicle Department and the General Purpose Control Department of the General Electric Company.

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This volume considers those principles and problems encountered in combining components to form a complete engine. It relies heavily upon other volumes in the series which deal with basic principles and problems related to components of an engine.

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PRODUCTION

Welding of Plastics. J. Alex Neumann and Frank J. Bockhoff. New York, Reinhold Publishing Corp., 1959. 279 pp., illus., diagrs., tables. $7.25.

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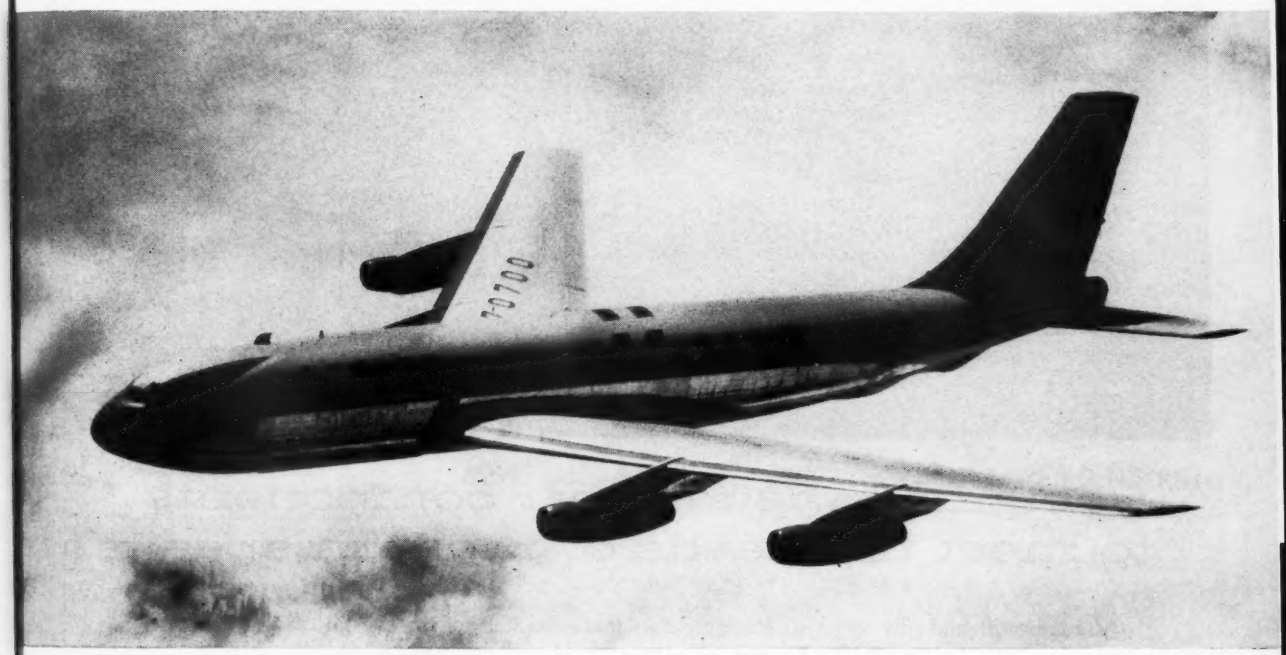

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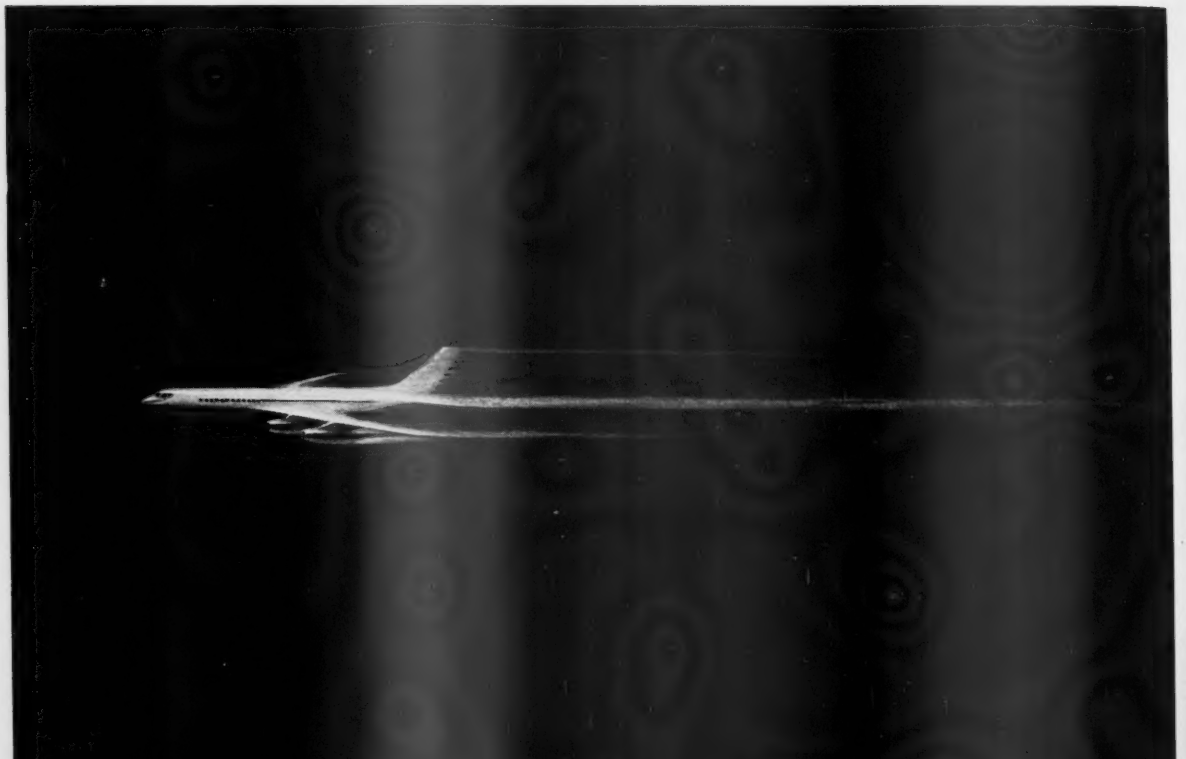

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STRUCTURES

Plastic Analysis of Structures. Philip G. Hodge, Jr. New York, McGraw-Hill Book Co., Inc., 1959. 364 pp., diagrs., tables. $10.50.

This book presents the techniques necessary in the analysis of structures beyond the elastic limit and emphasizes the conditions under which a plastic analysis is appropriate. Structures treated include beams and frames in bending, beams under combined stresses, plates, shells, and slabs with cutouts. Primary attention is given to the determination of stresses under static loads; but displacements, variable loadings, minimum weight design, and dynamic loadings are also treated. Two basic theorems are emphasized which enable lower and upper bounds on the load-carrying capacity of structures to be determined by independent considerations of static and kinematic conditions respectively.

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Dr. Hodge is Professor of Mechanics, Illinois Institute of Technology.

Introduction to Stress Analysis. Charles O. Harris. New York, The Macmillan Co., 1959. 330 pp., diagrs., tables. $7.50.

An introductory college text. The 14 chapters cover the following aspects of the subject: stress resultants in bars; stress and strain; uniform stress; torsion; flexural stress and deformation; stresses due to transverse forces on bars; shear and moment diagrams; buckling phenomena; superposition of stress patterns; factors which affect strength and deformation of materials; problems in plates and shells; strain energy and Castigliano's theorem; elementary plasticity; and two-dimensional axially symmetric stress distribution in a complete solid of revolution. The appendixes contain further material on the properties of an area, the moment-area method for elastic curve of a beam, some elements of the theory of elasticity, energy-of-distortion, the SR-4 electric resistance strain gage, and some modern notions of dry friction.

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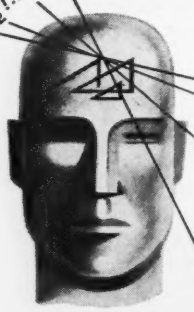

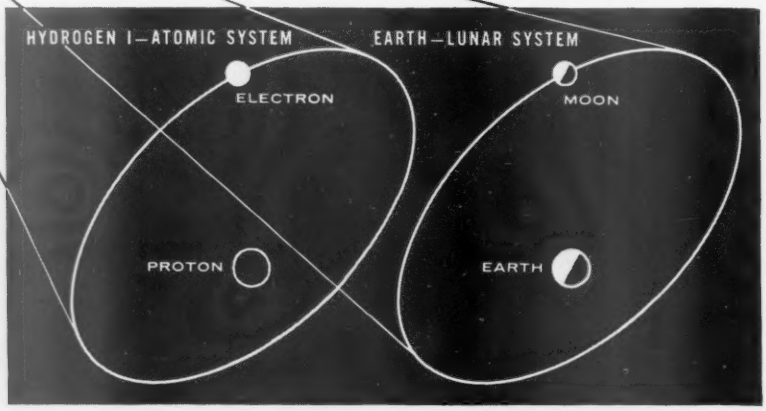

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Aeronautical Engineer—To teach lecture and laboratory courses in aircraft design. Up-to-date knowledge of the field required. Working and living conditions excellent; salary and opportunity very attractive. Write to Dean of Engineering, California State Polytechnic College, San Luis Obispo, Calif.

Physicist—To perform interplanetary travel studies covering optimization of trajectories, guidance schemes, and control methods. Also to establish lunar trajectories including lunar circumnavigation and landing procedures. Grade: GS-12/14, salary range: $8,810 pa to $11,595 pa. B.S. degree and 3 or more years' experience. Applications may be submitted on Standard Form 57, Application for Federal Employment, to the Director, Civilian Personnel Office, ABMA, Redstone Arsenal, Ala., Attn.: Paul C. Perry. Applications may be obtained from any first- or second-class Post Office or from any Civil Service Regional Office.

Nonchemical Propulsion Engineers—Experienced personnel with advanced degrees, for the following areas: Magnetogasdynamics, electromagnetic accelerators, electrostatic acceleration, plasma generation, plasma heat transfer and flow, ultra high vacuum, surface ionization, high-temperature thermodynamics, high-temperature nozzles. Write fully in confidence to Dr. Mark Peters, Bldg. 100, Dept. 2-MFA, Flight Propulsion Division, General Electric Co., Cincinnati, 15, Ohio.

Assistant Professor—To teach theory of structures, elasticity, dynamics. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Ore.

Electronic Scientists, Metallurgists, Physicists, Technologists, and Engineers (Aeronautical, Electrical, Electronic, Industrial, General, Mechanical and Power Plant)—Naval Air Material Center, Philadelphia 12, Pa., has an urgent need for qualified engineering and scientific personnel to fill vacancies in the above positions. The Center is currently engaged in an extensive program of aeronautical research, development, experimentation, and test operations for the advancement of Naval aviation. Experimental work is also being conducted in the guided-missile field. Starting salaries range from $4,490 to $8,330 per annum. Application for Federal Employment, Standard Form 57, should be filed with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the above address or information as to where they are available may be obtained from any first- or second-class post office.

Teaching—To teach undergraduate and graduate courses in aeronautical engineering. Applicant must have a Master's degree and, preferably, a Ph.D. degree. Rank and salary are open and will be determined by the candidate's qualifications. Excellent facilities are available with opportunity for research. A challenging opportunity is afforded for the development of graduate instruction and research in aero/space science and engineering at both the M.S. and Ph.D. degree levels, as well as in the undergraduate program. Applications should be sent to Prof. R. M. Pinkerton, Department of Mechanical Engineering, North Carolina State College, Raleigh, N.C.

Professors—The Virginia Polytechnic Institute, Blacksburg, Va., has permanent staff openings in the Department of Aeronautical Engineering. Full professors are needed in the fields of aircraft structures, space technology, and missile design for graduate teaching in the Master and Doctorate programs. Applicants must have the doctorate in either Aeronautical Engineering, Engineering Mechanics, or Mechanical Engineering. Other senior staff openings are available for teaching in the advanced undergraduate or graduate programs in Aeronautical Engineering. Salary and rank depend upon qualifications. Part-time research is available. Address inquiries with complete data and photograph to Head, Department of Aeronautical Engineering, Virginia Polytechnic Institute, Blacksburg, Va.

Professor—To teach undergraduate and graduate courses in aerodynamics and related fields, to design and supervise construction of teaching and research laboratory facilities and do part-time research. Advanced degree and industrial experience desirable. Salary and rank dependent upon qualifications. Address inquiries with complete personal data and photograph to Head, Department of Aeronautical Engineering, Alabama Polytechnic Institute, Auburn, Ala.

Engineers and Scientists—Openings in present program for six senior engineers and scientists, reporting directly to the Technical Director, to conduct fundamental research investigations in: (1) Dynamic handling qualities of vehicles, including analysis and application of human response measurements and definition of human input-output relationships, using advanced servo-analysis techniques. Requires exceptional interest and experience in the application of airframe dynamics and advanced servo theory to automatic flight control systems. (2) The study of dynamic requirements and methods of space vehicle flight control. Requires minimum of 6 years' experience in application of systems analysis techniques to automatic flight control systems. Knowledge of advanced mechanics essential. Requires U.S. citizenship, B.S., M.S., or Ph.D. in E.E., Mathematics, Physics, or Aeronautics. Send résumé to D. Johnston, Systems Technology, Inc., 1630 Centinela Ave., Inglewood 3, Calif.

Aerodynamics and Thermodynamicists—Ryan Aeronautical Co. in San Diego, Calif., needs seasoned aerodynamicists and thermodynamicists for its expanding engineering staff. (**Chief of Fluid Dynamics**)—Director of Aerodynamics and Thermodynamics Units in the analysis of propulsion, heat transfer, performance, stability,

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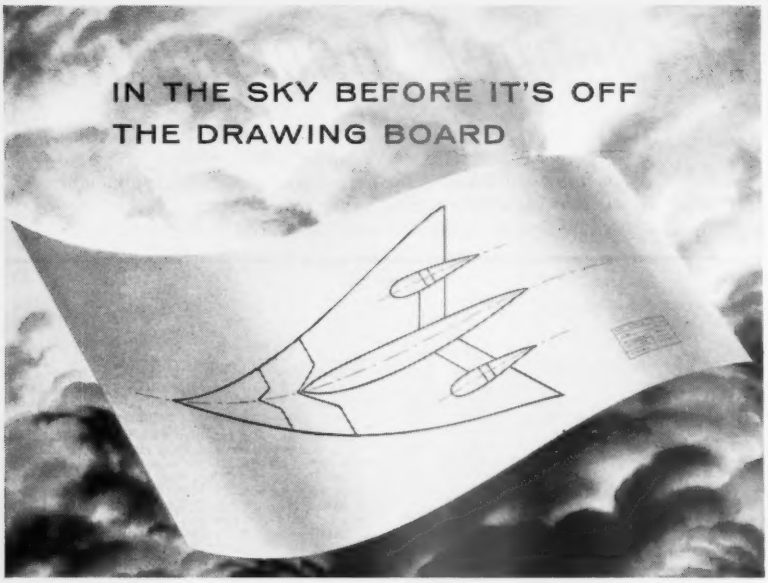

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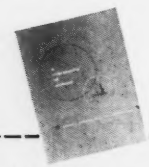

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Available

910. Research Engineer—Ph.D., M.E., age 30. Interested in experimental and theoretical research in heat transfer. Background in heat transfer, aerodynamics, and thermodynamics; 4 years' diverse experience. Presently assistant professor giving graduate courses in heat transfer and thermodynamics.

909. Sales Executive—Administrative Engineer—B.S. Ae.E., age 45. 20 years' sales engineering and executive experience with aircraft propellers, engines, and rockets. Has held positions as experimental test engineer, field engineer, product sales manager and manager, contract administration. Extensive experience with customer relations on maintenance engineering and development problems; also has had public relations and advertising experience.

908. Advanced Planning—Aeronautical Engineer with an enthusiasm for generating new business. B. of A.E., 20 years in missile and aircraft engineering, and sales development. Experienced in preliminary design and proposal preparation; structures analysis, design, and research; aerodynamic heating studies; production design and shop liaison. Served as staff consultant in preliminary design group of large company. Thoroughly conversant with small company operations, particularly sales development activities. Influential contacts. Will travel. Seeks opportunity to assist management in promoting growth of business through combined technical activities and market development planning. Age 41.

907. Aerodynamicist—Age 32. B.S. in Ae.E. Two years' research in low-speed wind tunnel; 5 years' experience in designing aircraft and industrial axial flow fans. Presently supervising design, test, and manufacture of fans, electronic cooling packages, vacuum pumps. Prefer medium-sized firm on West Coast.

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Mobile as a chess queen, quick as a rapier thrust and as lethal as brass knuckles, the Martin Orlando Lacrosse is a handy weapon in a scrap. Developed, designed and built for the U. S. Army, the Lacrosse can flit like a ghost behind the battle area, fire in the general direction of the target and be pin-pointed by a forward guidance station.

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